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EFFECTS OF STRIP-MINE DISCHARGES ON THE MARINE ENVIRONMENT NEAR CAPE ROSIER, MAINE

Federal Water Quality Administration
Needham Heights, Massachusetts

August 1970

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TABLE OF CONTENTS

	Page No.
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS	1
Summary	1
Conclusions	3
Recommendations	3
INTRODUCTION	5
Purpose	5
STUDY AREA	7
General Description	7
The Mining Operation	8
MATERIALS AND METHODS	11
Field Procedures	11
Laboratory Procedures	11
CHEMICAL RESULTS	15
Marine Waters	15
Sediments	19
Shellfish	22
Seaweeds	28
Ground Waters	30
BIOLOGY	37
Faunal Composition	37
Bottom Sediments	46

Page No.

Study Area 48

Data Evaluation of Effluent and Control Areas..... 48

Seasonal Benthic Population Trends..... 50

DISCUSSION..... 53

REFERENCES..... 57

APPENDIX..... 58

LIST OF TABLES

		Page No.
I	Ground Water Locations	12
II	Trace Metals in Cape Rosier Coastal Waters	16
III	Trace Metals in Sediments	20
IV	Metals Concentrations in Soft-shell Clams	24
V	Metals Concentrations in Seaweeds	29
VI	Metals Concentrations in Well Water	33
VII	Drinking Water Standards for Metals as Set Forth by Three Health Organizations	35
VIIIA	Percentage Values of Selected Study Organisms-Presented by Survey	39
VIIIB	Total Numbers and Percentage Values for Five Predominent Groups of Benthic Invertebrates	39
IX	Benthic Invertebrates	41
XA	Comparison of Total Numbers plus Percentage Values of Indicator Organisms in the Study Area	47
XB	Comparison of Number of Kinds in Effluent and Control Areas	47

LIST OF FIGURES

		Page No.
1.	Survey and Station Locations, Cape Rosier, Maine	9
2.	Callahan Mine Complex	10
3.	Water Supply Sampling Locations	32
4.	Comparison of Total Organisms and Selected Indicator Organisms	48

APPENDIX

		Page No.
A-1	Shellfish Closure	59
A-2	Station Locations - Cape Rosier, Maine	60
A-3	Benthic Organisms Per Square Meter, Cape Rosier, Maine - Phase I (Dec. 1967)	61
A-4	Benthic Organisms Per Square Meter, Cape Rosier, Maine - Phase II (May, 1968)	65
A-5	Benthic Organisms Per Square Meter, Cape Rosier, Maine - Phase III (July, 1968)	73
A-6	Benthic Organisms Per Square Meter, Cape Rosier, Maine - Phase IV (Sept. 1968)	79

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

At the request of the Maine Department of Sea and Shore Fisheries and the Maine Water and Air Environmental Improvement Commission, the Federal Water Quality Administration in cooperation with the United States Public Health Service initiated a survey of the coastal waters of Cape Rosier, Maine, in order to assess the effects of trace metal discharges to the marine environment of the area.

A series of four surveys were accomplished on a quarterly basis from December, 1967 to September, 1968. Shellfish, marine waters, seaweeds, sediments and ground water were collected during each of these surveys for trace-metal analysis. In addition, benthic organisms were also collected and enumerated in order to determine the effect of the mine's effluent on marine populations. A fifth survey was conducted by the Maine Department of Sea and Shore Fisheries during December, 1968, to assess the background trace metal levels in shellfish, marine water and sediments of the surrounding area.

Trace metal values of marine water are quite variable from station to station. Environmental parameters such as tidal stage, climatic conditions and utilization of trace substances by marine organisms at the time of sampling reduce the usefulness of trace metals in sea water as a basis of representative conditions.

Although trace metal levels in sediments vary from station to station,

zinc and copper values in the area of the Callahan Mine effluent are significantly higher than the average of all other stations. Sedimentary zinc values in the area of the effluent range from 2.6 to 5.7 times higher than the average of all other stations sampled. Sedimentary copper values in the effluent area range from 3.4 to 6.9 times higher than the average of all other stations sampled.

Metals concentrations detected in shellfish of the effluent area are high compared to background locations.

Zinc concentrations in seaweed from the effluent area range from 3 to 7 times higher than other stations. Copper concentrations in seaweed of the effluent area range from 2 to 3 times higher than other stations.

Analyses of well water collected from selected sites in the Cape Rosier area indicate that for the most part metals levels are within the limits for drinking water set by the U.S. Public Health Service. Some isolated cases of lead concentrations in excess of USPHS Standards are noted.

Marine benthic populations were sampled and evaluated during each of the four surveys. Two polychaete worms, Aricidea jeffreysii and Nephthys incisa, are the most abundant and uniformly distributed species of the Cape Rosier area. Comparisons of the seasonal trends of these and other species in the effluent and control areas indicate no abnormal effect to the marine adult benthic fauna, resulting from the strip-mine discharge.

Conclusions

1. Zinc and copper values in sediments, seaweeds and shellfish of the effluent area indicate a heavy influx of these substances to the marine environment of Goose Cove. Although limits for metals concentration in shellfish have not been promulgated by any agency, it appears that the concentrations found in shellfish near the outfall may represent a potential health hazard, as Goose Cove is presently open for the taking of shellfish for human consumption (see page A-1).

2. Except for isolated cases of excessive lead concentrations, trace metal levels in well water are within USPHS drinking water standards.

3. Benthic population trends evaluated during the course of the survey indicate that the adult fauna of the Goose Cove area is able to tolerate the effects of the mine's effluent.

Recommendations

1. Because Goose Cove is open for taking of shellfish at the present time and a potential public health hazard, represented by the high metals concentrations present in shellfish of the Goose Cove area exists, it is recommended that further monitoring of this resource be undertaken by State authorities.

2. In order to validly interpret the long-term effects of trace-metal loadings to the marine environment, future biological work with relation to metals should concentrate on the larval stages of organisms

rather than adult populations. Work with the much more sensitive juvenile or larval stage will yield information on growth supression and toxicity at this stage of development, which does not become obvious in the adult populations until life cycles are completed.

3. It is further recommended that future monitoring of public water supplies of the area be carried out to determine if the high lead concentrations detected at two Stations (11F and 14F) are persistant, as lead contamination of water supplies presents a definite public health hazard.

INTRODUCTION

Heavy metals discharged to the hydrosphere have long created serious pollution problems because of the adverse effect excessive amounts of metals have on aquatic life and the overall degradation of water quality by them. The immediate and long range effects of heavy metals upon the life histories of marine organisms are not completely understood or readily predicted. For these reasons particular attention is given to anomalous heavy metals concentrations as potential hazards to the flora and fauna of the marine environment.

Purpose

In November, 1967, the Maine Department of Sea and Shore Fisheries and the Maine Water and Air Environmental Improvement Commission, requested the FWPCA, Northeast Region, to conduct an investigation in the Cape Rosier coastal waters in order to assess the potential hazards to marine life which may result from the discharge of metals and other chemical wastes during strip mining operations.

Goose Falls, a small cove located on the southeast portion of Cape Rosier, Maine, is the source of sea water for the aqueous flotation and separation process of the Callahan copper and zinc strip mine located nearby. Goose Falls also receives the effluent from this process.

A series of four surveys were conducted by the FWPCA from the period

Purpose (Cont.)

of December, 1967 to September, 1968 - the results of which have been used in the determination of water quality in the area, the effects it may have on marine life, and the potential public health hazard posed by metals discharges. A fifth survey was conducted by the Maine Department of Sea and Shore Fisheries to assess the background trace metal level in shellfish, marine water and sediments of the area.

STUDY AREA

General Description

Cape Rosier is located in the central coastal section of the State of Maine and constitutes a portion of Hancock County (See Fig. 1). Cape Rosier is a small, hilly, peninsular land body known for its natural beauty and esthetic quality. The Cape is surrounded by Castine Harbor and the tidal waters of the Bagaduce River to the north, the open waters of the Penobscot Bay to the west, and the island studded East Penobscot Bay to the south. Prominent land marks in relation to the Cape include the City of Castine (north), Isleboro Island (west), and Little Deer Isle (southeast). Other portions of Hancock County lie to the east and include the Town of Brookville.

The coastline of Cape Rosier is ruggedly typical of Maine. Many natural coves penetrate the shoreline and numerous fingerlike land formations penetrate the waters edge forming excellent shelters for man and wildlife alike. Picturesque islands of various sizes dot the northern and southern tips of the Cape.

The economy of Hancock County is principally dependent upon the fishing industry. This area is recognized as one of the world's largest producers of lobsters and soft shell clams. Other shellfish harvested for profit include crabs and scallops.

Cape Rosier itself has a history of mining activity. The Callahan Complex shown in Figure 2 is located in the vicinity of Goose Pond and

includes part of the Rosier Mines, now defunct. Prior to this operation Goose Pond, a tidal water pond was the only predominent inland water body Goose Pond has been drained, and presently a small, shallow, fresh water pond and a man made ditch, Weir Cove ditch, exists in this area.

The Mining Operation

The Callahan Mining Corporation started a copper and zinc strip mine in early 1968. The mining process involves removal of copper-zinc ore from the strip-mine area to a crushing mill . The ore is crushed to a size of 3/8 of an inch and is then wet ground in a ball mill. Various chemicals are then added to promote selective froth flotation: a copper froth concentrate is removed first and then the zinc froth concentrate is removed.

The ground materials remaining after the copper and zinc minerals have been floated off plus the filtrate are pumped to a tailing pond. The mixture of solid material and sea water, or slurry as it is commonly called, is estimated to settle to approximately 55 percent solids. The remaining water is pumped or allowed to overflow into an effluent pond. The water from the effluent pond is then discharged to Goose Cove. Rain and ground water which collects in the open pit mine is periodically pumped directly to the effluent line. Figure 2 depicts the general flow of water through the mine complex.

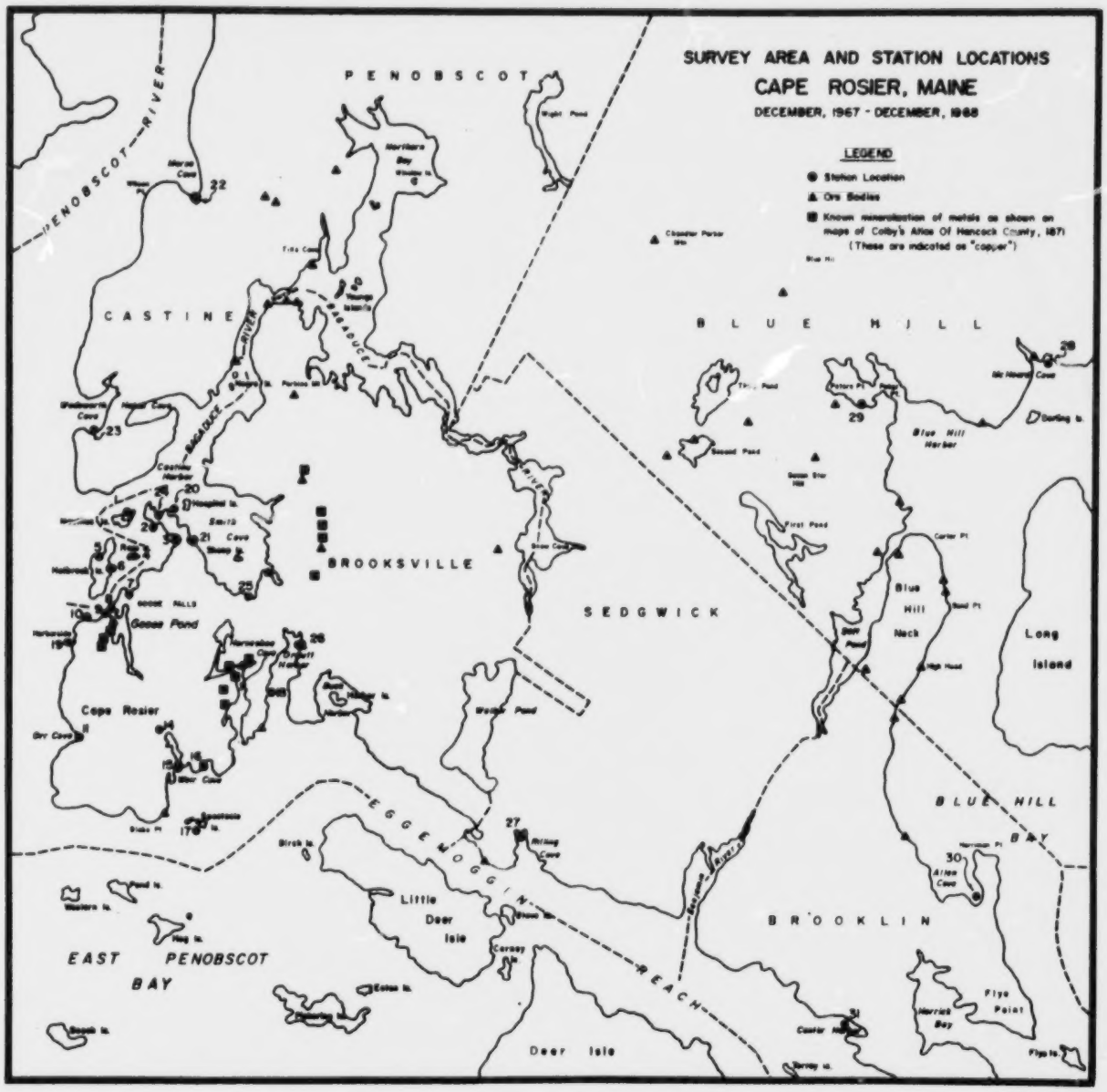

SURVEY AREA AND STATION LOCATIONS
CAPE ROSIER, MAINE
DECEMBER, 1967 - DECEMBER, 1968
LEGEND
Station Location
Ore Bodies
Known mineralization of metals as shown on maps of Colby's Atlas Of Hancock County, 1871 (These are indicated as "copper")
PENOBSCOT
PENOBSCOT RIVER
CASTINE
BROOKSVILLE
SEDGWICK
BLUE HILL
BLUE HILL BAY
BROOKLIN
Cape Rosier
Goose Pond
Blue Hill Neck
Long Island
Little Deer Isle
Deer Isle
EGGEMOGGIN REACH
EAST PENOBSCOT BAY
Blue Hill Harbor
Flye Point

FIGURE 1

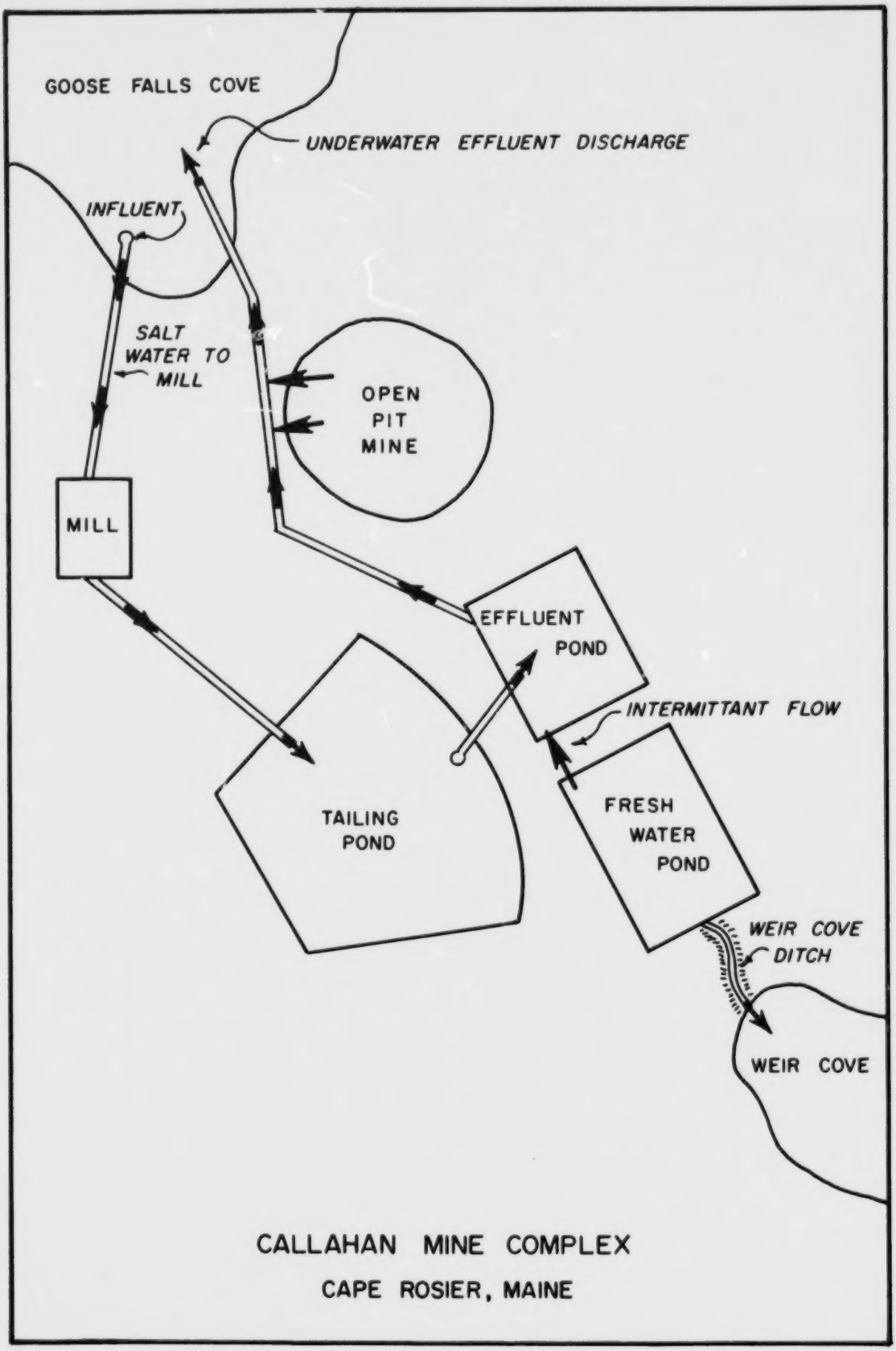

GOOSE FALLS COVE
UNDERWATER EFFLUENT DISCHARGE
INFLUENT
SALT WATER TO MILL
OPEN PIT MINE
MILL
EFFLUENT POND
INTERMITTANT FLOW
TAILING POND
FRESH WATER POND
WEIR COVE DITCH
WEIR COVE
CALLAHAN MINE COMPLEX
CAPE ROSIER, MAINE

FIGURE 2

MATERIALS AND METHODS

Field Procedures

Marine water samples were collected one foot off the bottom at all stations with a Kemmerer water sampler. Each sample was transferred to a one liter plastic bottle and acidified for preservation.

Benthic samples were taken with a Petersen grab, an aliquot portion removed and preserved with acid for sediment analysis and the remainder put through a 0.5 mm screen. Macrofaunal organisms retained on the screen were removed to a jar and preserved with formaldehyde for laboratory analysis.

Seaweed samples, Ascophylum nodosum, were hand picked at the closest possible proximity to the actual station location. These samples were iced to retard biological degradation.

Ground water samples were collected by personnel of the Maine Water and Air Environmental Improvement Commission at selected well sites around the survey area. (See Table 1).

All clam samples were hand collected by the Maine Department of Sea and Shore Fisheries.

Laboratory Procedures

Marine and ground water, seaweeds and sediments were analyzed for zinc, cadmium, nickel, copper and lead concentrations by atomic absorption spectrophotometry (Perkin Elmer Model 303). December, 1967 and May,

TABLE I

GROUND WATER LOCATIONS - Dec. 1967 - Sept. 1968
Cape Rosier, Brookville, Maine - Harborside Area

Station Number	
1F	From Property of Brainard Farnham. This is a 63 foot drilled well which serves two houses - one now vacant. There is some copper pipe, but remainder is plastic. This has replaced older copper pipe and when it was all copper in 1962 a test showed .1 mg/l copper, The well is at first house on right on old mine road.
2F	From property of Malcolm Gray. This is a dug well which serves two houses (one near road and now vacant and one further back). The cover is nailed on. The pipe to the sink is plastic, but faucet and a short piece of pipe is brass. The well is reported to be about 10 ft. (or a little more) deep. The well is on the east side of the road at Harborside.
3F	From property of Richard Howard Sr. The well is on west side of road at Harborside. It is a 315 ft. drilled well. Pipe is all plastic. Samples taken from basement at pressure tank.
4F	From property of Murray Bray, but is a community well serving ten houses, including Mr. Tracy Howard. Flows out of well casing in pit where sample was taken. This is in area behind third house on right, west of Harborside Corner.
5F	From property of James Babbridge. A spring delivers water to house by plastic pipe with a very little copper in the house. This is the last house on shore side before cove west of Harborside Corner.

TABLE I (Cont.)

GROUND WATER LOCATIONS - DEC. 1967 - SEPT. 1968
Cape Rosier, Brookville, Maine
Road from Harborside to Rosier Grange
All houses listed were sampled.

Station Number	
6 F	Fifth house, west side. Property of B. Redman. This is a dug well less than 10 feet deep. Sample was dipped from well after breaking ice one foot below top of well.
7 F	Ninth house, east side. Robert T. Howard. Spring with house over it across the road and back 200 feet toward Harborside. Sample dipped from source. Also serves eighth house west side of road near cemetary entrance.
8 F	Tenth house, and store, west side. Carl Leach. Spring--plastic pipe.
9 F	Eleventh house, east side G. Dyer. Spring on C. Leach property-serves this and also next house. This spring is covered and is located only a few yards from drainage ditch to Weir Cove.
10 F	Callahan Mining Corp. Drilled well near Office and laboratory. 290 feet deep, sampled at pump.
	Main Road -- Rosier Grange toward Brooksville.
11 F	Red house on east side of Weir Cove on side road - spring on property of Forest Tyson; water flows to cellar in iron pipe. Sampled at pump.
12 F	Second house on east side of road - J.R. Gray property, Spring - concrete block and wooden cover. Sample dipped from source.
13 F	Horseshoe Market - Perry Smith property, Drilled well 92 feet deep, plastic pipe. Sampled in washroom. Apartment on second floor has copper pipe. This is at the "Creek School" location on USGS Map.
14 F	Third house, west side, not counting trailer and market property of Rosco Rankin - has water rights to spring on Holbrook Wildlife Sanctuary. Plastic Pipe; sampled at sink.

Laboratory Procedures (Cont.)

1968 analyses were performed at the Hudson-Delaware Basins Office of the FWQA. Subsequent analyses were performed at the New England Basins Office of the FWQA.

Clam samples from all five surveys were analyzed for zinc, copper, iron, manganese, nickel, cobalt, cadmium, lead, and chromium at the U. S. Public Health Service Laboratory at Narragansett, Rhode Island. Atomic absorption spectrophotometry was also used for these analyses.

Benthic macrofauna collected during the first four quarterly surveys were separated and microscopically identified at the New England Basins Office of the FWQA. Identification was performed utilizing standard biological keys, and results were mathematically evaluated to detect trends in the data.

RESULTS

Marine Waters

Quantities of trace metals found in sea water overlying the biological sampling sites are shown in Table II.

To delineate the five surveys accomplished during the course of this program, phase designations have been used as follows:

Phase I - December, 1967

Phase II- May, 1968

Phase III - July, 1968

Phase IV - September, 1968

Phase V - December, 1968

Phase I - (Dec. 1967)

Trace metal values in marine waters during the initial survey showed variable concentrations of these elements at almost all stations. This appears to be an indication of the active geology of the area, and must be taken into consideration when assessing the potential hazards of trace metal contamination in the marine environment.

Values for zinc (in mg/l) ranged from 1.640 at Station 9 to 0.047 at Station 8, and an average value of 0.361 mg/l was obtained for all stations.

Copper values ranged from 0.302 at Station 9 to 0.042 at Station 7 and an average value of 0.113 mg/l was obtained for all stations. Other trace elements (Cd, Ni, and Pb) were somewhat lower.

TRACE METALS IN CAPE ROSIER COASTAL WATERS, MG/L

TABLE II

DECEMBER, 1967 TO JULY, 1968

Station	PHASE I					PHASE II					PHASE III				
	Zn	Cd	Ni	Cu	Pb	Zn	Cd	Ni	Cu	Pb	Zn	Cd	Ni	Cu	Pb
1	0.088	0.003	0.061	0.070	0.08	<0.01	<0.01	<0.01	0.070	<0.01	0.07	0.03	0.14	0.14	0.45
2	0.132	0.001	0.004	0.109	0.01	<0.01	<0.01	<0.01	0.090	<0.01	0.05	0.03	0.06	-	0.20
3	0.84	0.002	0.050	0.093	0.02	<0.01	<0.01	<0.01	0.105	<0.01	0.07	0.03	0.10	0.06	0.50
4	0.116	0.001	0.020	0.087	0.00	<0.01	<0.01	<0.01	0.100	<0.01	0.11	0.03	0.10	0.12	0.35
7	0.049	0.000	0.021	0.042	0.00	<0.01	<0.01	<0.01	0.120	<0.01	0.06	0.03	0.18	-	0.30
8	0.047	0.001	0.020	0.117	0.09	<0.01	<0.01	<0.01	0.090	<0.01	0.07	0.03	0.10	0.13	0.43
9	1.640	0.001	0.009	0.302	0.04	<0.01	<0.01	<0.01	0.100	<0.01	0.06	0.04	0.06	0.08	0.40
10	0.138	0.002	0.031	0.117	0.08	<0.01	<0.01	<0.01	0.095	<0.01	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	0.649	0.001	0.008	0.187	0.00	<0.01	<0.01	<0.01	0.140	<0.01	0.28	0.05	0.14	-	0.40
16	0.105	0.001	0.025	0.073	0.00	<0.01	<0.01	<0.01	0.130	<0.01	0.10	0.03	0.06	0.14	0.40
17	-	-	-	-	-	0.90	<0.01	<0.01	0.370	-	0.09	0.03	0.10	0.18	0.15
18	-	-	-	-	-	<0.01	<0.01	<0.01	0.195	<0.01	0.07	0.03	0.06	0.15	0.20
19	-	-	-	-	-	-	-	-	-	-	0.07	0.04	0.10	0.10	0.35
20	-	-	-	-	-	-	-	-	-	-	0.04	0.03	0.14	-	0.33
21	-	-	-	-	-	-	-	-	-	-	0.05	0.03	0.10	0.12	-
Goose Pond Br.	0.166	0.002	0.026	0.047	0.00	1.30	<0.01	<0.01	0.110	0.02	-	-	-	-	-

TRACE METALS IN CAPE ROSIER COASTAL WATERS, MG/L

TABLE II (cont)

SEPTEMBER, 1968 TO DECEMBER, 1968

	PHASE IV					PHASE V				
Station	Zn	Cd	Ni	Cu	Pb	Zn	Cd	Ni	Cu	Pb
1	0.105	0.04	0.06	0.230	0.27	-	-	-	-	-
2	0.035	0.04	0.06	0.090	0.27	-	-	-	-	-
3	0.030	0.04	0.10	0.065	0.22	-	-	-	-	-
4	0.030	0.04	0.06	0.080	0.22	-	-	-	-	-
7	0.035	0.04	0.14	0.105	0.22	-	-	-	-	-
8	0.030	0.025	0.14	0.090	0.27	-	-	-	-	-
9	0.040	0.025	0.10	0.100	0.31	-	-	-	-	-
15	0.060	0.04	0.06	0.135	0.19	-	-	-	-	-
16	0.035	0.04	0.14	0.090	0.27	-	-	-	-	-
17	0.135	0.04	0.10	0.200	0.22	-	-	-	-	-
18	0.040	0.04	0.06	0.100	0.31	-	-	-	-	-
19	0.035	0.04	0.06	0.075	0.27	-	-	-	-	-
20	0.045	0.025	0.06	0.105	0.22	-	-	-	-	-
21	0.095	0.04	0.10	0.245	0.27	-	-	-	-	-
23	-	-	-	-	-	0.02	0.02	0.10	0.035	0.20
24	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	0.02	0.02	0.10	0.030	0.20
27	-	-	-	-	-	0.03	0.03	0.06	0.08	0.23
28	-	-	-	-	-	0.015	0.01	0.01	0.015	0.08
29	-	-	-	-	-	0.015	0.03	0.06	0.02	0.20
30	-	-	-	-	-	0.02	0.03	0.10	0.035	0.27
31	-	-	-	-	-	0.04	0.03	0.10	0.045	0.20
32	-	-	-	-	-	0.015	0.02	0.10	0.035	0.20

Phase II -(May 1968)

Except for copper, metals levels in coastal waters of the Cape Rosier area decreased markedly during the Phase II survey, and in most cases were below the minimum detection limit of the instrument used to analyze them.

Copper concentrations varied somewhat from station to station as compared to the Phase I results, but an average value of 0.132 mg/l for all stations closely approximates the average of the first survey.

Phase III - (July 1968)

Metals levels during the Phase III survey were generally higher than levels found during Phase II. Again copper was an exception to this variability with an average value of 0.122 mg/l for all stations.

Zinc values ranged from 0.28 mg/l at Station 15 to 0.04 mg/l at Station 20 and an average value of 0.085 mg/l was obtained for all stations.

Lead values increased markedly during this Phase, reaching a maximum value of 0.50 mg/l at Station 3, and an average value of 0.37 mg/l for all stations.

Phase IV - (Sept. 1968)

During this Phase, average copper concentrations for all stations remained somewhat similar to previous surveys at 0.122 mg/l. Zinc concentrations ranged from 0.135 mg/l at Station 17 to 0.03 mg/l at Stations 3, 4, and 8.

The average zinc value for all stations was 0.054 mg/l. Lead concentrations remained high, maximum values of 0.31 mg/l being found at Station 9 and 18. The average lead concentrations for all stations was 0.25 mg/l.

Phase V - (Dec. 1968)

Background samples collected during this time period tended to substantiate high metals concentrations normal to the Cape Rosier area. Although these samples were apparently free from the effects of pollutional influx, trace metal levels were fairly high at all stations, averaging 0.022, 0.079, 0.037, and 0.20 mg/l for zinc, nickel, copper, and lead, respectively.

Sediments

Trace metal levels in sediments of the Cape Rosier area readily reflect the long term input of the mining operation on the benthic environment, as these sediments act as a storehouse of materials. Results of three Phases (II, IV, and V) are shown on Table III. During all phases stations near the Callahan Mine effluent (7, 8, and 9) have average trace metal concentrations significantly higher than the rest.

In May, 1968, zinc values (in mg metal/kg dry material) ranged from 99.5 at Station 8 to 12.2 at Station 1. Average zinc values at Stations 7 and 8 were 2.6 times higher than the average of all other stations.

During the September, 1968 survey, trace metal levels in sediments generally increased at all stations. Zinc values range from 228.00 mg/kg dry material at Station 9 to 23.01 mg metal/kg dry material at

TABLE III

Trace Metals in Sediments (Mg metal/kg dry material)
Cape Rosier, Maine, May and September, 1968

Station	Phase II May Zn	Cd	Ni	Cu	Pb	Phase IV September Zn	Cd	Ni	Cu	Pb	
1	12.2	0.26	7.09	5.51	3.59	27.23	0.189	15.32	6.79	7.79	
2	36.0	0.32	8.80	5.62	2.97	48.96	0.372	23.42	18.89	5.85	
3	43.3	0.30	11.22	8.37	3.05	43.68	0.283	17.80	8.74	8.90	
4	18.5	0.18	8.88	4.81	2.40	44.12	0.204	14.30	1818.07*	75.99*	
7	47.8	0.36	13.64	9.93	3.35	52.63	0.343	28.60	18.02	10.75	
8	99.5	0.44	21.96	26.79	5.27	215.92	0.469	29.50	65.04	12.07	
9	32.6	0.18	18.37	7.69	3.17	228.00	0.912	28.66	67.10	12.77	
15	24.1	0.28	13.45	10.39	3.62	34.74	0.342	15.66	8.93	6.46	
16	14.1	0.15	13.50	1.96	2.35	24.48	0.191	12.24	4.51	3.44	
17	35 8	0.15	6.78	1.01	2 80	-	-	-	-	-	
18	37.8	0.15	14.82	3.39	3.15	23.01	0.192	12.27	5.68	3.60	
19	-	-	-	-	-	41.07	0.246	21.76	5.86	3.60	
20	-	-	-	-	-	43.27	0.367	25.67	8.43	12.69	
21	-	-	-	-	-	48.17	0.225	26.01	9.59	12.78	
Ave.	36.2	0.25	12.59	7.77	3.25	67.33	0.333	20.86	18.96	8.36	
Max.	99.5	0.44	21.96	26.79	5.27	228.00	0.912	29.50	1818.07	75.99	
Min.	12.2	0.15	6.78	1.01	2.35	23.01	0.189	12.24	4.51	3.16	
Ave. of 7&8	73.65	0.40	17.80	18.36	4.31	221.96	0.690	29.08	66.07	12.42	Ave. of 8&9
Ave. of others	28.27	0.22	11.43	5.42	3.01	39.21	0.268	19.37	9.54	7.54	
Factor, 7&8 to others	2.6	1.8	1.6	3.4	1.4	5.7	2.6	1.5	6.9	1.6	Factor 8&9 to others

* Not included in Average

TABLE III (Cont.)

Trace Metals in Sediments (mg metal/kg dry material)
Cape Rosier, Maine December, 1968 (Phase V)

Station	Zn	Cd	Ni	Cu	Pb
22	16.11	0.18	4.17	3.11	2.22
23	9.80	0.13	4.72	1.54	2.97
8,9	109.23	0.62	14.69	19.74	19.28
24	32.04	0.21	7.92	2.90	4.38
25	26.94	0.13	11.08	3.48	6.74
26	24.87	0.18	11.66	3.34	6.80
27	12.33	0.08	3.80	2 53	6.48
28	5.35	0.01	2.34	0.74	1.00
29	14.64	0.10	7.12	2.48	6.30
30	17.21	0.07	12.05	2.41	3.44
31	9.02	0.08	4.14	1.41	2.44
32	10.18	0.04	5.22	1.67	2.09
St. George River	31.25	0.13	12.28	6.14	14.51

Note: Phase III Sediment Samples - Laboratory accident. No values Reported.

Sediment samples not collected during Phase I (refer to Interim Report on Cape Rosier).[1]

Sediments (Cont.)

Station 18. Average zinc values at Stations 8 and 9 were 5.7 times higher than the average of all other stations. It should be noted that at Station 4 during this Phase extremely high copper and lead values were noted in the sediment (1818.07 mg Cu/kg dry material and 75.99 mg Pb/kg dry material. Trace metal levels in seaweeds and clams at this station, although high, do not reflect such an abnormal concentration to be present. For this reason it is felt that an enriched piece of material was picked up at this Station during sampling and is not representative of conditions of the area.

Copper values for all stations during this Phase ranged from 1818.07 mg metal/kg dry material at Station 4 to 4.51 mg metal/kg dry material at Station 16. Average copper values for Stations 8 and 9 were 5.7 times higher than the average of all other stations, excluding Station 4.

Background samples collected during December, 1968 (Phase V) reflect the same general trend of sediment metals concentrations found in previous surveys. Stations near the effluent area demonstrated much higher metal values, especially with respect to copper and zinc, than other stations.

Shellfish

For some time it has been understood that shellfish, expecially the bivalves, have the ability to selectively concentrate heavy metals to levels greater than those found within their environment. Many heavy metals are known to be detrimental to human health. The contamination of edible shellfish by heavy metals, therefore, can present a serious health hazard. In general, shellfish accumulate metals by osmosis

Shellfish (Cont.)

directly from the hydrosphere and by feeding on organisms in lower trophic levels which also have the faculty of metals uptake.

The fact that Goose Cove (Figure 2) receives the effluent from the zinc and copper metal processing complex of the Callahan Mine operation indicates the possibility of metals entering the marine water and shellfish of Cape Rosier, Maine. Metals analyses were conducted on the softshell clam, Mya arenaria, for the determination of the presence and concentration of nine metals.

Clams were qualitatively sampled from selected areas on the coast of Cape Rosier and included the Goose Cove effluent area. The bulk of these data are presented on Table IV.

Phase I

Shellfish in the effluent area (Stations 8 and 9) exhibited slightly higher metals concentrations than other stations. Copper concentrations in shellfish of this area were 4.8 mg/kg wet tissue compared to average copper concentrations of 2.9 mg/kg wet tissue for all other stations. Zinc concentrations in shellfish of the effluent area were 18.8 mg/kg wet tissue compared to 13.8 mg/kg wet tissue for all other stations. Other metals (See Table V) showed similar trends in concentrations.

Phase II

Metals levels in shellfish during this Phase generally increased at all

TABLE IV

METALS CONCENTRATIONS IN SOFT SHELL CLAMS - Mg/Kg WET TISSUE
CAPE ROSIER, MAINE

	Phase I (December, 1967)									Phase II (May, 1968)								
Station	Zn	Cu	Fe	Mn	Ni	Co	Cd	Pb	Cr	Zn	Cu	Fe	Mn	Ni	Co	Cd	Fe	Cr
1	14.7	2.8	93.6	2.4	0.2	0.2	0.2	2.4	0.2	16.6	2.7	89.8	68.2	0.7	0.1	0.2	4.6	4.2
2	12.6	3.2	123.8	5.9	0.2	0.2	0.2	1.5	1.4	13.8	2.3	262.0	17.3	0.1	0.7	0.1	1.1	1.3
4	15.2	3.0	138.9	6.0	0.2	0.2	0.2	1.4	1.1	14.4	4.3	678.2	43.8	0.0	0.9	0.0	3.2	1.6
6	13.3	3.1	154.0	5.9	0.2	0.2	0.2	1.8	0.8	16.6	2.6	513.5	8.0	0.2	0.5	0.2	2.4	2.2
7	13.6	2.4	75.1	1.3	0.2	0.2	0.2	1.2	0.3	16.6	4.6	281.8	3.9	0.0	0.7	0.1	2.1	1.4
8	18.5	4.9	526.0	20.2	0.2	0.2	0.3	4.9	1.4	45.2	8.4	1709.0	204.3	0.1	1.2	0.8	19.5	3.9
9	19.1	4.6	759.7	21.4	6.2	0.2	0.3	2.4	1.2	28.4	6.8	131.1	23.4	2.1	0.7	0.3	17.0	2.1
11	13.7	2.7	286.7	39.9	0.3	0.6	0.1	2.2	2.0	16.2	1.6	122.4	22.4	0.6	0.0	0.1	0.5	0.6
14	-	-	-	-	-	-	-	-	-	14.9	2.5	682.2	28.6	1.4	0.8	0.1	2.5	2.5

TABLE IV (CONT.)

METALS CONCENTRATIONS IN SOFT SHELL CLAMS - Mg/Kg WET TISSUE

CAPE ROSIER, MAINE

Station	Phase III (July, 1968)									Phase IV (September, 1968)								
	Zn	Cu	Fe	Mn	Ni	Co	Cd	Pb	Cr	Zn	Cu	Fe	Mn	Ni	Co	Cd	Pb	Cr
1	20.1	1.8	327.0	15.6	2.5	0.5	0.1	2.4	1.2	13.9	3.1	1028.0	341.2	1.2	1.3	0.1	2.5	1.2
2	17.3	1.8	177.3	10.9	0.8	0.0	0.1	2.2	1.2	12.6	2.0	115.8	2.9	0.7	1.9	0.1	1.1	0.5
4	18.1	1.6	189.2	8.3	0.2	0.0	0.1	1.9	0.2	43.6	7.5	1181.0	80.6	2.0	0.5	0.7	14.0	1.5
6	15.0	2.2	145.5	3.2	0.2	0.0	0.1	1.6	0.4	15.6	3.3	477.0	5.5	2.7	0.3	0.1	1.7	1.7
7	15.4	1.6	76.7	1.8	0.1	0.0	0.1	1.5	0.2	17.4	2.9	580.3	19.9	1.1	0.0	0.1	1.9	1.2
8	69.6	4.8	868.5	37.4	0.6	0.5	0.6	5.3	1.3	35.6	4.6	1942.0	101.8	1.1	0.7	0.6	12.4	1.7
9	36.5	3.0	123.1	2.9	0.0	0.0	0.3	2.5	0.4	13.4	4.0	690.0	174.3	1.9	1.0	0.2	2.2	1.2
11	14.6	2.3	330.2	34.1	0.8	0.4	0.1	0.2	1.3	12.5	2.6	430.2	3.6	0.2	0.2	0.2	2.2	1.3
14	16.4	1.4	305.5	34.3	1.5	0.5	0.1	1.4	0.2	16.5	2.2	2971.0	191.4	1.5	1.5	0.2	5.6	1.4

TABLE IV(Cont.)

REFERENCE STATIONS

PHASE V

METALS CONCENTRATIONS OF SOFT SHELL CLAMS MG/KG WET TISSUE

December, 1968

Station	Cu	Zn	Cd	Pb	Co	Fe	Cr	Mn	Ni
8	2.9	34.7	0.2	7.1	1.2	1722.0	3.3	189.4	1.61
22	2.0	16.9	0.1	2.4	0.5	766.4	6.4	21.6	2.2
23	1.4	11.6	0.1	1.3	0.2	287.5	2.7	19.2	1.5
24	1.2	12.5	0.2	1.8	0.0	876.3	3.4	21.6	1.5
25	1.1	9.8	0.0	0.0	0.0	196.7	3.2	4.0	1.5
26	2.9	13.8	0.0	1.1	0.0	199.1	4.5	4.3	0.8
27	0.9	10.4	0.0	1.7	0.0	225.8	5.1	21.5	2.1
28	0.9	8.9	0.0	1.0	0.0	355.8	5.1	21.5	2.1
29	1.6	8.8	0.1	0.8	0.3	654.8	2.6	17.1	1.4
30	1.7	11.0	0.1	0.9	0.3	530.3	1.3	4.6	0.9
31	1.3	10.9	0.4	0.9	0.3	262.6	2.6	3.8	1.0

Phase II (Cont.)

stations.

Copper and zinc concentrations in shellfish of the effluent area averaged 7.6 and 36.8 mg metal/kg wet tissue, respectively. Copper and zinc concentrations in shellfish of all other areas averaged 2.9 and 15.6 mg metal/kg wet tissue, respectively. There was also a significant increase of lead in shellfish of the effluent area.

Phase III

Zinc concentrations increased slightly for all stations, and significantly in the effluent area (3310 mg Zn/kg wet tissue). Copper concentrations generally decreased during this Phase to 1.8 mg/kg wet tissue at all stations outside the effluent area, and 3.9 mg/kg wet tissue in the effluent area. Lead and chromium concentrations in shellfish of the effluent area also decreased. while cadmium remained constant.

Phase IV

Zinc concentrations increased to 18.9 mg/kg wet tissue in shellfish of all stations outside the effluent area and decreased to 24.5 mg metal/kg wet tissue in the effluent area. Copper concentrations in shellfish increased in both the effluent area and other stations. Lead and chromium concentrations in shellfish of the effluent area increased, while cadmium remained constant.

Phase V

Copper concentrations in shellfish of the effluent area decreased to 2.9 mg metal/kg tissue, while zinc increased to 34.7 mg/kg. Lead and cadmium also decreased while chromium increased. Other stations sampled during this Phase cannot be directly ompared with previous phases, because station locations were changed.

Seaweeds

Metals concentrations in seaweeds Ascophylum nodosum from the Cape Rosier area reflect long-term metals loadings in the marine environment. Seaweeds, unlike clams, obtain metals by direct exchange with the hydrosphere, utilizing dissolved materials. On the other hand, clams more readily utilize particulate matter which contains metals previously assimilated such as detrital material and aggregates. For this reason, seaweeds may be considered a primary consumer of metals from the environment, and clams a secondary one utilizing metals that have already passed through at least one trophic level.

Table V shows metals concentrations in seaweeds in the Cape Rosier area reported on dry weight basis. As in the case with clams and sediments, seaweeds at Station 8 and 9 near the effluent of the Callahan Mine, exhibited metals concentrations much higher than surrounding areas.

Generally, seaweeds at Station 9 contained higher concentrations of metals during April and July, while in September, highest values were reported at Station 8.

TABLE V

METALS CONCENTRATIONS IN SEAWEEDS, MG/KG DRY MATERIAL

CAPE ROSIER - APRIL 1968 TO SEPTEMBER 1968

	PHASE II - APRIL					PHASE III - JULY					PHASE IV - SEPTEMBER				
Station	Zn	Cd	Ni	Cu	Pb	Zn	Cd	Ni	Cu	Pb	Zn	Cd	Ni	Cu	Pb
1	113.07	0.66	3.29	7.36	4.47	37.0	0.33	0.50	2.61	2.03	56.8	0.30	4.28	5.98	3.93
2	92.53	0.66	13.09	8.86	4.63	34.6	0.22	1.10	2.36	1.25	49.0	0.27	7.86	5.66	3.06
3	103.05	1.11	2.09	5.43	4.84	31.9	0.14	0.70	1.06	1.06	117.7	0.22	4.77	6.20	2.86
4	105.23	0.63	22.74	7.26	3.90	39.4	0.23	1.18	2.28	1.97	107.2	0.25	3.57	6.19	2.61
7	207.12	1.29	2.98	5.05	4.79	49.0	0.17	1.74	2.90	1.39	90.5	0.38	5.45	5.72	4.47
8	256.20	0.14	5.44	12.81	6.69	91.0	0.21	1.21	2.88	1.21	871.3	0.82	6.54	22.99	8.71
9	478.92	4.16	3.90	19.26	4.05	119.4	0.79	6.21	7.01	2.48	230.1	0.49	3.08	9.04	4.64
10	131.36	0.78	5.53	6.31	4.06	-	-	-	-	-	-	-	-	-	-
15	107.73	0.71	8.93	6.24	5.39	41.1	0.32	1.02	3.24	2.05	48.0	0.25	3.75	4.52	0.95
16	98.35	0.93	9.08	7.42	3.89	15.9	0.21	0.15	3.02	0.63	51.9	0.24	3.65	4.68	1.90
17	94.51	0.62	4.55	6.24	4.10	33.6	0.22	1.49	1.75	1.49	143.7	0.50	9.95	4.88	5.19
18	109.21	1.27	3.43	6.60	4.40	20.4	0.16	0.61	-	1.22	69.5	0.19	5.24	3.96	1.16
19	-	-	-	-	-	48.4	0.22	5.39	3.86	-	97.6	0.33	5.51	5.02	2.98
20	-	-	-	-	-	54.0	0.19	1.73	2.54	1.54	65.0	0.84	3.42	4.31	1.85
21	-	-	-	-	-	25.2	0.18	0.78	1.82	1.25	39.5	0.08	6.30	7.06	1.85
Max.	478.92	4.16	22.74	19.26	6.69	119.4	0.79	6.21	7.01	2.48	871.3	0.84	6.54	22.99	8.71
Min.	92.53	0.14	2.09	5.05	3.89	15.9	0.14	0.15	1.06	0.63	39.5	0.08	3.08	3.96	0.95
Ave. 8 & 9	367.56	2.15	4.67	16.04	5.37	105.2	0.50	3.71	4.94	1.84	550.7	0.66	4.81	16.02	6.68
Ave. Others	116.22	0.87	7.57	6.68	4.45	33.6	0.22	0.94	2.40	1.45	78.0	0.37	5.31	5.35	2.73
Factor 8 & 9 to Others	3.2	2.5	0.6	2.4	1.2	3.1	2.3	4.0	2.1	1.3	7.1	1.8	0.9	3.0	2.4

Seaweeds (Cont.)

Average values for zinc at Stations 8 and 9 were significantly higher for all surveys than the average of all other stations, ranging from 3.1 to 7.1 times higher during July and September, respectively.

Maximum values for zinc occurred at Station 8 during September when a concentration of 871.3 mg/kg dry material was detected in the seaweeds. The highest value occurring at Station 9 was 478.92 mg/kg during April.

Copper concentrations in seaweeds were also high in the effluent area, ranging from 2 to 3 times higher than the average of all other stations during July and September, respectively.

Maximum copper concentrations in seaweeds at Station 8 occurred during September (22.99 mg/kg), while at Station 9 the maximum occurred in April (19.26 mg/kg).

The abundance of other metals (Cd, Ni, and Pb) was not as pronounced in the effluent area as copper and zinc. However, in most cases they were above values found at other stations.

Ground Waters

Ground water collected from locations near the Callahan Mine complex were analyzed for the metals zinc, cadmium, nickel, copper, and lead. The purpose of these analyses was to determine whether or not the mine was causing metals contamination of the well water used for drinking by local inhabitants of Cape Rosier. When subjected to water, metals

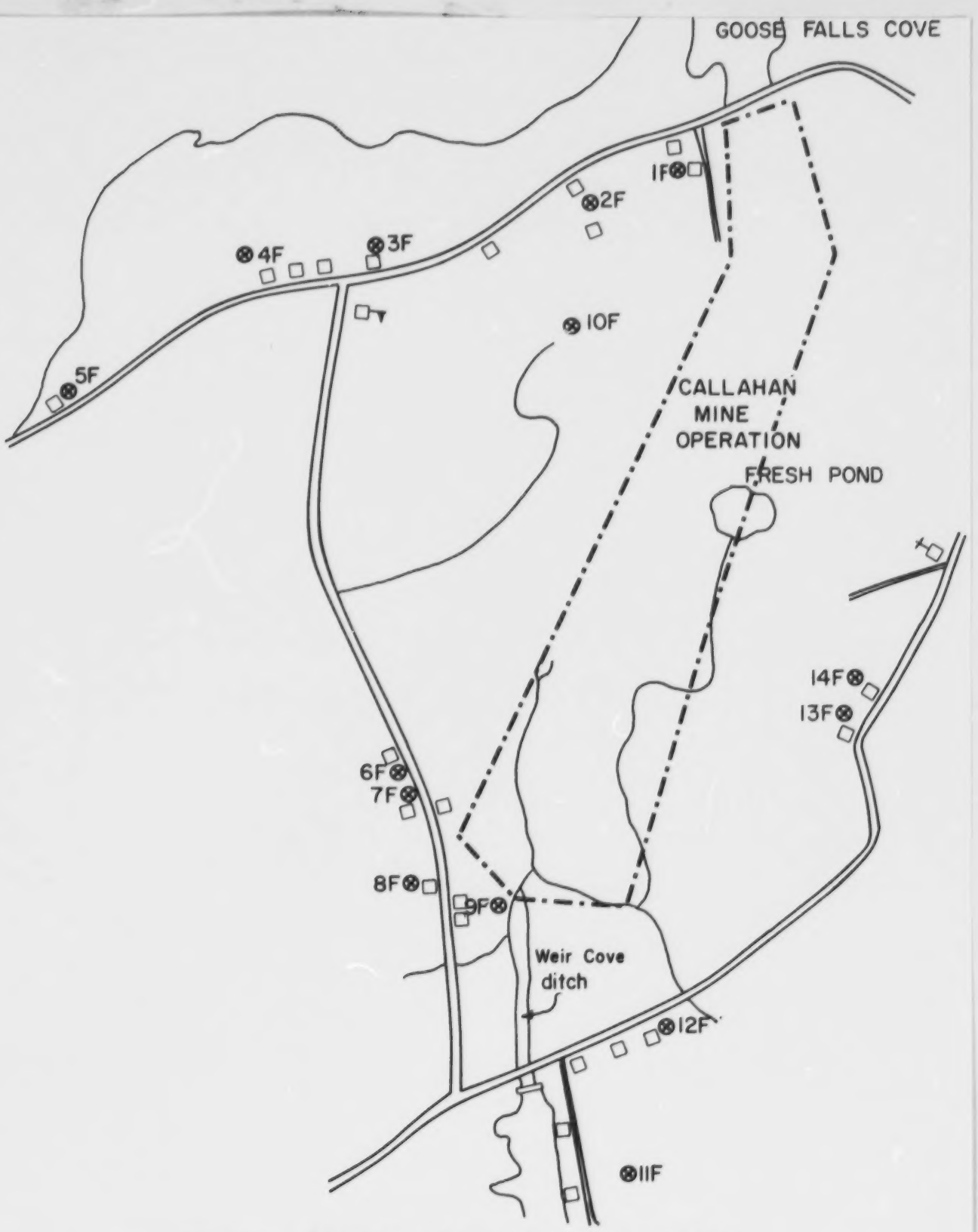
Ground Waters (Cont.)

can be leached from the ground and transported into ground water systems from which well water is drawn. If incidents of heavy metal loadings occur, serious health hazards can result.

Table VI lists the concentrations of the five metals analyzed, and Figure 3 indicates the approximate sample locations. Table VII which indicates the drinking water standards for metals as set forth by three health organizations serves as an aid in distinguishing if the Cape Rosier well waters are meeting recommended and allowable concentrations for certain metals.

Since nickel is not listed on the standards table, no direct conclusions can be derived for this metal except that it is not considered harmful to human beings in small concentrations. Zinc, cadmium and copper appear to be well within acceptable limits for drinking water for Phases I, III, and IV.

The data indicate that lead was also within limits except during Phase I and III for certain stations. During Phase I Stations 11F and 14F had lead concentrations of 0.09 mg/l and 0.08 mg/l respectively. These concentrations are greater than the maximum allowable USPHS limit of 0.05 and approach WHO International and WHO European limits of 0.10.



WATER SUPPLY SAMPLING LOCATIONS
CAPE ROSIER, MAINE
DECEMBER, 1967 - DECEMBER, 1968

FIGURE 3

TABLE VI

Metals Concentration - mg/l in Well Water
Cape Rosier, Maine December, 1967 - September, 1968

Station	PHASE I Zn	Cd	Ni	Cu	Pb	PHASE II Zn	Cd	Ni	Cu	Pb
1F	1.5	0.0	0.02	0.5	0.0	< .01	< .01	< .01	0.4	< .01
2F	1.6	0.001	0.02	0.01	0.0	1.3	< .01	0.02	0.1	< .01
3F	0.1	0.0	0.02	0.05	0.02	0.4	< .01	0.02	0.1	< .01
4F	0.1	0.002	0.03	0.03	0.0	< .01	< .01	0.01	0.07	< .01
5F	1.6	0.001	0.03	0.06	0.0	0.8	< .01	0.02	0.2	< .01
6F	0.1	0.0	0.0	0.2	0.01	-	-	-	-	-
7F	0.02	0.001	0.01	0.005	0.0	< .01	< .01	< .01	0.03	< .01
8F	1.6	0.0	0.05	0.02	0.01	< .01	< .01	0.15	0.04	< .01
9F	0.03	0.0	0.04	0.02	0.01	< .01	< .01	< .01	0.04	< .01
10F	0.07	0.0	0.05	0.02	0.02	< .01	< .01	< .01	0.06	< .01
11F	1.6	0.001	0.03	0.03	0.09	-	-	-	-	-
12F	0.04	0.0	0.03	0.01	0.0	< .01	< .01	< .01	0.04	< .01
13F	0.05	0.001	0.03	0.14	0.01	< .01	< .01	< .01	0.08	< .01
14F	0.05	0.0	.04	0.05	0.08	< .01	< .01	< .01	0.09	< .01
Goose Pond At Weir Cove	0.03	0.0	.03	0.02	0.0	< .01	< .01	< .01	0.04	< .01

Phase I - December, 1967

Phase II - May, 1968

TABLE VI (Cont.)

Metals Concentration - mg/l in Well Water
Cape Rosier, Maine December, 1967 - September, 1968

Station	PHASE III					PHASE IV				
	Zn	Cd	Ni	Cu	Pb	Zn	Cd	Ni	Cu	Pb
1F	-	-	-	0.03	-	0.0	< .004	< .01	< .005	< .03
2F	1.07	0.01	<.01	0.05	< .03	0.68	< .004	< .01	0.03	< .03
3F	0.11	< .004	<.01	0.25	< .03	0.08	< .004	< .01	< .01	< .03
4F	0.04	< .004	<.01	0.04	< .03	0.08	< .004	< .01	< .005	< .03
5F	0.47	< .004	<.01	0.15	< .03	0.45	< .004	< .01	0.120	< .03
6F	-	-	-	-	-	0.09	-	-	-	-
7F	0.03	< .004	<.01	0.04	< .03	< 0.01	< .004	< .01	< .005	< .03
8F	0.72	< .004	<.01	0.04	< .03	-	-	-	-	-
9F	0 07	< .004	<.01	0.0	0.05	0.01	< .004	< .01	< .005	< .03
10F	0 04	< .004	<.01	0.03	< .03	0.02	< .004	< .01	< .005	< .03
11F	-	-	-	-	-	-	-	-	-	-
12F	0.02	< .004	<.01	0.02	0.05	-	-	-	-	-
13F	0.03	0.008	<.01	-	< .03	0.01	< .004	< .01	0.03	< .03
14F	0.04	< .004	<.01	0.11	0.1	0.05	< .004	< .01	0.25	< .03
Goose Pond at Weir Cove	-	-	-	-	-	-	-	-	-	-

Phase III - July, 1968

Phase IV - September, 1968

TABLE VII

Drinking Water Standards For Metals (mg/l)
as set forth by three Health Organizations

ELEMENT	WHO INTERNATIONAL - 1958			WHO EUROPEAN -(1961)		U.S.P.H.S. (1962)	
	Permissive Limit	Excessive Limit	Maximum Allowable	Recommended Limit	Tolerance Limit	Recommended Limit	Maximum Limit
Cadmium	--	--	--	--	0.05	--	0.01
Chromium (Hexavalent)	--	--	0.05	--	0.05	--	0.05
Copper	1.0	1.5	--	3.0*	--	1.0	--
Iron	0.3	1.0	--	0.1	--	0.3	--
Lead	--	--	0.1	--	0.1	--	0.05
Manganese	0.1	0.5	--	0.1	--	0.05	--
Zinc	5.0	15	--	5.0	--	5.0	--

* After 16 hours contact with new pipes;

But water entering a distribution system should have less than 0.05 mg/l of copper.

Ground Waters (Cont.)

During Phase III both Stations 9F and 12F have lead concentrations of 0.05 mg/l. These are maximum allowable by USPHS Standards. Station 14F has a concentration for lead of 0.10 mg/l. This is two times greater than the USPHS figure and equal to maximum for WHO International and equals the tolerance limit for WHO European.

BIOLOGY

A marine survey in the water surrounding Cape Rosier, Maine was performed to evaluate the effects of a strip mine effluent on benthic invertebrate life in the outfall area.

Sampling was undertaken outside of Goose Cove to establish a control area which was relatively free of the strip mine discharge and had a bottom sediment composition similar to the effluent area. The survey was initiated in December 1967, before the strip mine was operational to establish the composition of the benthic community for comparison with the three surveys (May, July, and September, 1968) performed after the mine began discharging the waste. Surveys were conducted during different times of the year to establish seasonal patterns and determine if any organisms exerted a major controlling influence on the community. A comparison of population trends of benthic invertebrate life within the control and effluent area was made to evaluate the influence of the strip mine effluent.

Faunal Composition

Benthic marine animals are divided into two ecologically different groups: the epifauna and the infauna. (9) The epifauna comprises those animals living upon or associated with rocks, stones, shells, pilings, and vegetation either sitting upon or crawling on these substrata. The infauna comprises those animals living buried in or digging into the substratum. They are most abundant below the intertidal zone, which was the area sampled for these surveys.

The infaunal environment of the sublittoral zone is more stable than the epifaunal environment. It is constantly covered with water and is therefore not subjected to drastic temperature changes, winter ice, and land predators, such as shore birds. The infauna, being continuously exposed to the strip mine effluent, would be the most likely to show any adverse effects that might be attributed to the mine. Because of this environmental stability and because of their uniform distribution over broad geographical areas, the infaunal forms were emphasized in this study.

Diversity in kinds and numbers of benthic marine fauna was found in the level, muddy, bottom communities of the sheltered coves of Cape Rosier and of Nautilus and Ram Islands.

The predominent form of benthic life, in terms of total numbers, was the marine polychate worm. This class of invertebrates made up an average of 76% (Table VIIIB) of the total December to September sample population. Second and third in order of abundance were the amphipods (Class Crustacea), averaging 12% and the nematodes, which averaged 6%. Cumaceans (Class Holothurioidea) and bivalves were fourth and fifth in numbers, each comprising 1% of the population.

Two polychaete worms, Arcidea jeffreysii and Nephthys incisa, both members of the infauna, were the most abundant and uniformly distributed species of the Cape Rosier Survey. Aridicea jeffreysii comprised from 33% to 39% (Table VIIIA) of the total organisms in each of the four surveys and was found in 78% (Table IX) of the sample stations. Nephthys incisa

TABLE VIII

A-Percentage Values[1] of Selected[2] Study Organisms-Presented by Survey

Cape Rosier, Maine 1967-68

Organisms	Survey December	May	July	September
Aricidea jeffreysii	39.35%	37.62%	33.30%	46.63%
Nephthys incisa	45.22%	10.06%	10.74%	18.55%
Nematoda (Class)	.12%	22.44%	2.87%	1.52%
Corophium volutator	1.55%	6.50%	7.53%	3.84%
Prionospio steenstrupi	-	2.70%	4.60%	4.75%

B-Total Numbers and Percentage Values[1] for Five Predominent Groups of Benthic Invertebrates - Presented by Survey

Cape Rosier, Maine 1967-68

Survey	Polychaetes Total No.	% *	Amphipods Total No.	% *	Nematodes Total No.	% *	Cumaceans Total No.	% *	Bivalves Total No.	% *
December	52,528	92.17%	2,670	4.68%	70	.12%	644	1.13%	798	1.40%
May	94,459	60.28%	15,260	9.74%	35,154	22.44%	2,072	1.32%	882	.56%
July	75,738	72.20%	23,212	22.13%	3,010	2.87%	966	.92%	1,288	1.23%
September	50,470	80.86%	9,072	14.53%	952	1.52%	672	1.08%	658	1.05%
Average	68,299	76.38%	12,554	12.77%	9,796	6.74%	1,088	1.11%	906	1.06%

[1] Percentage values refer to percent contribution to total number of organisms in survey

[2] Selected organisms are the first five listed in Table IX

* Percent of total organisms

contributed 10% to 45% (Table VIIIA) of the total organisms in each of the surveys and was present in 91% (Table IX) of the stations. Together, these two species of marine polychaete worms comprised 55% of the total number of organisms in the survey (Table IX).

Aricidea jeffreysii, a member of the Paraonidae family, is a small, delicate, threadlike worm living a sedentary existance in a fragile tube while feeding indiscriminately in the upper layers of the sediment. Paraonids such as Acididea jeffreysii are thought to be more widely distributed than their sparse records might indicate since they are in general, very small and easily overlooked. (3) Only a sieve with a small mesh size opening such as the .595 mm used in this survey will retain them. This polychaete was first in order of abundance making up 38% of all animals (Table IX).

The second most dominant organism, Nephthys incisa, constituting 16% of all organisms (Table IX) is also a non-selective deposit feeder which burrows into the flocculent layer that lies loosely on the surface of the sediment and into the gray silty layer just below. This marine worm has an eversible proboscis with a pair of horny teeth enabling it to perform as a carnivore, but the existing literature has reported it to be a deposit feeder when found in soft, muddy bottoms. (4) Since predators are not believed to be stable members of the infauna, it is important to realize that in the Cape Rosier area Nephthys incisa feeds on the sediments. It is, therfore, considered to be an acceptable organism for use in the comparison of the control and effluent stations.(5) The two organisms discussed above, Aricidea jeffreysii and Nephthys incisa,

TABLE NO. IX

BENTHIC INVERTEBRATES

Listed in Order of Abundance

CAPE ROSIER 1967 - 1968

Rank	Species	Number of Individuals	o/o of Total Organisms	Cumulative o/o by Number	o/o Occurrence in all Samples Taken	Class
1	Aricidea jeffreysii	145,404	38,161	38,161	78.26	Polychaeta
2	Nephthys incisa	64,386	16.898	55.059	91.30	Polychaeta
3	Nematoda	39,186	10.284	65.343	34.78	Nematoda
4	Corophium volutator	21,420	5.622	70.965	60.87	Crustacea
5	Prionospio steenstrupi	12,040	3.160	74.125	34.78	Polychaeta
6	Scolecolepides viridis	10,108	2.653	76.778	21.74	Polychaeta
7	Marine oligochaete	7,910	2.076	78.854	2.17	Olicochaeta
8	Phoxerphalus holbolli	7,658	2.010	80.864	47.83	Crustacea
9	Ampithoe spp.	7,406	1.944	82.808	34.78	Crustacea
10	Capitella capitata	6,958	1.826	84.634	58.70	Polychaeta
11	Scoloplos acutus	5,726	1.503	86.137	36.96	Polychaeta
12	Cumaceans	4,354	1.143	87.280	60.87	Holothurioidea
13	Pholoe minuta	4,298	1.128	88.408	34.78	Polychaeta
14	Ampelisca macrocephala	3,976	1.044	89.452	54.35	Crustacea
15	Harmothoe extenuata	3,052	.812	90.264	34.78	Polychaeta
16	Tryphosa pinguis	3,052	.801	91.065	21.74	Crustacea
17	Ninoe nigripes	2,870	.753	91.818	54.35	Polychaeta
18	Apistobranchus tullbergi	2,786	.731	92.549	10.87	Polychaeta
19	Allorchestes littoralis	2,142	.562	93.111	13.04	Crustacea
20	Polydora cilita	1,428	.374	93.485	4.35	Polychaeta
21	Phyllodoce groenlandica	1,386	.364	93.849	26.09	Polychaeta
22	Ammotrypane aulogaster	952	.250	94.099	41.30	Polychaeta
23	Spio setosa	952	.250	94.349	2.17	Polychaeta
24	Amphicteis gunneri	854	.224	94.573	15.22	Polychaeta

Rank	Species	Number of Individuals	o/o of Total Organisms	Cumulative o/o by Number	o/o Occurrence in all Samples Taken	Class
25	Mya arenaria	770	.202	94.775	30.44	Pelecypoda
26	Cirratulus arandis	756	.198	94.793	17.39	Polychaeta
27	Clymella torquata	742	.195	95.168	13.04	Polychaeta
28	Gammarus marinus	728	.191	95.359	6.54	Crustacea
29	Cossura longocirrata	658	.173	95.532	17.39	Polychaeta
30	Nucula proxima	602	.158	95.690	21.74	Pelecypoda
31	Periploma fragilis	574	.151	95.841	6.52	Pelecypoda
32	Echinarachnius parna	504	.132	95.973	10.87	Echinoidea
33	Mytilus edulis	476	.125	96.098	23.91	Pelecypoda
34	Melita dentata	448	.118	96.216	8.70	Crustacea
35	Ostracod	448	.118	96.334	15.22	Crustacea
36	Diplocirrus hirsutus	406	.107	96.441	15.22	Polychaeta
37	Harmothoe imbricata	392	.103	96.544	17.39	Polychaeta
38	Eteone lactea	378	.099	96.643	28.26	Polychaeta
39	Lumbrineris tenuis	351	.092	96.735	26.09	Polychaeta
40	Polydora ligni	334	.088	96.823	17.39	Polychaeta
41	Littorina littorea	322	.084	96.907	6.52	Gastropoda
42	Macoma balthica	308	.081	96.988	23.91	Pelecypoda
43	Pectinaria gouldii	308	.081	97.069	17.39	Polydora
44	Ampharete acutifrons	252	.066	97.135	6.52	Polychaeta
45	Nereis arenaceodonta	252	.066	97.201	10.87	Polychaeta
46	Strongylocentrotus drobachiensis	252	.066	97.267	19.56	Echinoidea
47	Glycera dibranchiata	238	.062	97.329	4.35	Polychaeta
48	Nephthys caeca	224	.059	97.388	8.70	Polychaeta
49	Anonyx nugax	210	.055	97.443	2.17	Crustacea
50	Leptocheirus pinguis	196	.051	97,494	6.52	Crustacea
51	Spisula solidissima	196	.051	97,545	2.17	Pelecypoda
52	Clymenella zonalis	168	.044	97,589	4.35	Polychaeta
53	Eulalia bilineata	168	.044	97,633	4.35	Polychaeta
54	Lumbrineris fragilis	168	.044	97.677	15.22	Polychaeta

Rank	Species	Number of Individual	% of Total Organisms	Cumulative % by Number	% Occurrence in all Samples Taken	Class
55	Spisula polynma	154	.040	97.717	2.17	Pelecypoda
56	Eteone longa	140	.037	97.754	6.52	Polychaeta
57	Edotea triloba	140	.037	97.791	10.87	Crustacea
58	Acmaea testudinalis	126	.033	97.824	6.52	Gastropoda
59	Cythura carinata	112	.029	97.853	2.17	Crustacea
60	Scoloplos rubustus	112	.029	97.882	6.52	Polychaeta
61	Terebellides stroemi	112	.029	97.911	8.70	Polychaeta
62	Tellina agilis	112	.029	97.940	10.87	Pelecypoda
63	Arabella iricolor	98	.026	97.966	2.17	Polychaeta
64	Lyonsia hyalina	98	.026	97.992	4.35	Pelecypoda
65	Macoma tenta	98	.026	98.018	2.17	Pelecypoda
66	Nassarius trivittatus	84	.022	98.040	6.52	Gastropoda
67	Paraphoxus spinosus	84	.022	98.062	6.52	Crustacea
68	Paraonis fulgens	70	.018	98.080	2.17	Polychaeta
69	Acarina	56	.015	98.095	4.35	Arachnida
70	Gnathia spp.	56	.015	98.110	2.17	Crustacea
71	Lysianopsis alba	56	.015	98.125	2.17	Crustacea
72	Notomastus luridus	56	.015	98.140	4.35	Polychaeta
73	Ampharete gracilis	42	.011	98.151	2.17	Polychaeta
74	Amphicteis extenuata	42	.011	98.162	2.17	Polychaeta
75	Corophium cylindricium	42	.011	98.173	2.17	Crustacea
76	Glycera capitata	42	.011	98.184	2.17	Polychaeta
77	Meterythrops robusta	42	.011	98.195	4.35	Crustacea
78	Pherusa affinis	42	.011	98.206	4.35	Polychaeta
79	Potamilla neglecta	42	.011	98.217	6.52	Polychaeta
80	Sternaspis fossor	42	.011	98.228	2.17	Polychaeta
81	Asterias forbesi	28	.007	98.235	2.17	Asteroidea
82	Caprellidea	28	.007	98.242	4.35	Crustacea

Rank	Species	Number of Individuals	o/o of Total Organisms	Cumulative o/o by Number	o/o Occurrence in all Samples Taken	Class
83	Cardita borealis	28	.007	98.249	2.17	Pelecypoda
84	Cladocera	28	.007	98.256	4.35	Crustacea
85	Lepidonotus squamatus	28	.007	98.263	4.35	Polychaeta
86	Nephthys bucera	28	.007	98.270	4.35	Polychaeta
87	Platynereis megalops	28	.007	98.277	2.17	Polychaeta
88	Talorchestia longicornis	28	.007	98.284	2.17	Crustacea
89	Ampelisca spinipes	14	.004	98.288	2.17	Crustacea
90	Amphipholis squamata	14	.004	98.292	2.17	Ophiuroidea
91	Ampithoe rubricata	14	.004	98.296	2.17	Crustacea
92	Calliopius laeviusculus	14	.004	98.300	2.17	Crustacea
93	Dulichia porrecta	14	.004	98.304	2.17	Crustacea
94	Gammarus locusta	14	.004	98.308	2.17	Crustacea
95	Grubia compta	14	.004	98.312	2.17	Crustacea
96	Jaeta marina	14	.004	98.316	2.17	Crustacea
97	Jassa marmorata	14	.004	98.320	2.17	Crustacea
98	Littorina obtusata	14	.004	98.324	2.17	Gastropoda
99	Maldanopsis elongata	14	.004	98.328	2.17	Polychaeta
100	Nephthys picta	14	.004	98.332	2.17	Polychaeta
101	Nereis virens	14	.004	98.336	2.17	Polychaeta
102	Paqurus pollicaris	14	.004	98.340	2.17	Crustacea
103	Paranatis speciosa	14	.004	98.344	2.17	Polychaeta
104	Pherusa plumosa	14	.004	98.348	2.17	Polychaeta
105	Stegocephalus inflatus	14	.004	98.352	2.17	Crustacea
106	Syllidae	14	.004	98.356	2.17	Pelecypoda
107	Yoldia limatula	14	.004	98.360	2.17	Pelecypoda
Miscellaneous (unidentified)		6,264				
Total Number of Organisms		381,029				

were found to be the most dominant, stable, and uniform of all the benthos collected and are believed to have a similar ecological niche in the upper layers of the substratum. They indiscriminately ingest the substratum, where precipitating metals would be concentrated, in search of organic nutrients. The feeble currents of muddy bottom areas allow organic matter to settle out, thus providing an adequate source of nutrients for large numbers of deposit feeders. Any heavy metals, such as zinc and copper, that are present would also settle to the bottom. Appreciable amounts of these metals, e.g., zinc, copper, iron, lead, cobalt, cadmium, etc., are disruptive to ecosystems -- copper, in particular may have a devastating effect on biological systems. Consequently, comparisons between the effluent area (Stations 8 and 9) and selected stations in the control area (Stations 1, 2, 3, and 4) will chiefly involve the two deposit feeding polychaete worms, Aricidea jeffreysii and Nephthys incisa, but will include comparisons of total organisms and total kinds as well.

Third in order of abundance were the nematodes (10%) found in 34% of the stations (Table IX). A majority (31,920) of the total number of nematodes (39,186) were found at Station 17 during the May survey (Table VIII). A small amphipod, Corophium volutator, was fourth in numerical order (5%) and present at 69% of the stations. Although it does inhabit a burrow and can feed there, it may leave it, either to feed or possibly to undertake periodic migration.(6) Because of its ability to migrate once it becomes a member of the epifauna, this animal is considered to be too unstable to be used as an index species, even though it feeds on organic detritus and was found in large numbers (2,828) at Station 8 of the effluent area during the May survey.

Fifth in numerical order was the small spionid Prionospio steenstrupi contributing 3% of the total population (Table IX). This marine worm is a selective deposit feeder that utilizes two large tentacles on its head to carry fine particles from the surface to its mouth. Ecologically this is important because this polychaete feeds in the niche where precipitating metals would accumulate. Although it was present in large numbers at Station 8 during the May survey, Prionospio steenstrupi has not been used as a principle index specie because it was not found in any of the December survey samples.

Those species that contributed less than one percent of the total population are considered "fringe species" because of their lack of numbers and uniformity (Table IX). Of the total 107 kinds, 93 fringe species contributed only 8% of the total organisms. The remaining 14 of the 107 kinds contributed 89% of the total number of organisms (Table IX). The two most dominant species composed 55% of the organisms collected.

The great diversity of benthos found in the majority of the soft bottom station indicates a normal, clean environment, but lack of numbers and uniformity of these fringe species prevent using them for comparison between effluent and control stations. These fringe species are used, however in comparing the total kinds of the two areas (Table XB).

Bottom Sediments

A field analysis of bottom sediments of the effluent and control stations had an average of 75-100% silt, except Station 4 which has an average of 55% silt. Fine sand and small amounts of gravel made up the remaining

TABLE X

A comparison of Total Numbers
Plus Percentage Values of Indicator
Organisms in the Study Areas

Cape Rosier, Maine 1967 - 68

	Control Area (Stations 1, 2,3,4)	Effluent Area (Stations 8, 9)	Control and Effluent area Combined
Total Number of Organisms	237,580	35,322	272,902
Total Number of *Aricidea jeffreysii*	135,422	4,620	140,042
Total Number of *Nephthys incisa*	51,926	5,516	57,442
Percent *Aricidea jeffreysii*	57.00%	13.08%	51.32%
Percent *Nephthys incisa*	21.86%	15.62%	21.05%
Cumulative Percentage (*A. jeffreysii* and *N. incisa*)	78.86%	28.70%	72.37%

B-Comparison of numbers of kinds
(actual and average figures) In Effluent
and Control Areas

Cape Rosier, Maine 1967 - 68

Station	Average No. of Kinds per Meter sq	No. of Kinds per Meter sq. December	May	July	September
Control					
1	20.0	12	13	28	27
2	19.5	11	16	24	27
3	13.5	12	11	17	14
4	19.0	18	16	26	16
Effluent					
8	18.0	15	27	19	11
9	19.8	18	23	21	17

percentages of sediment materials.

Study area

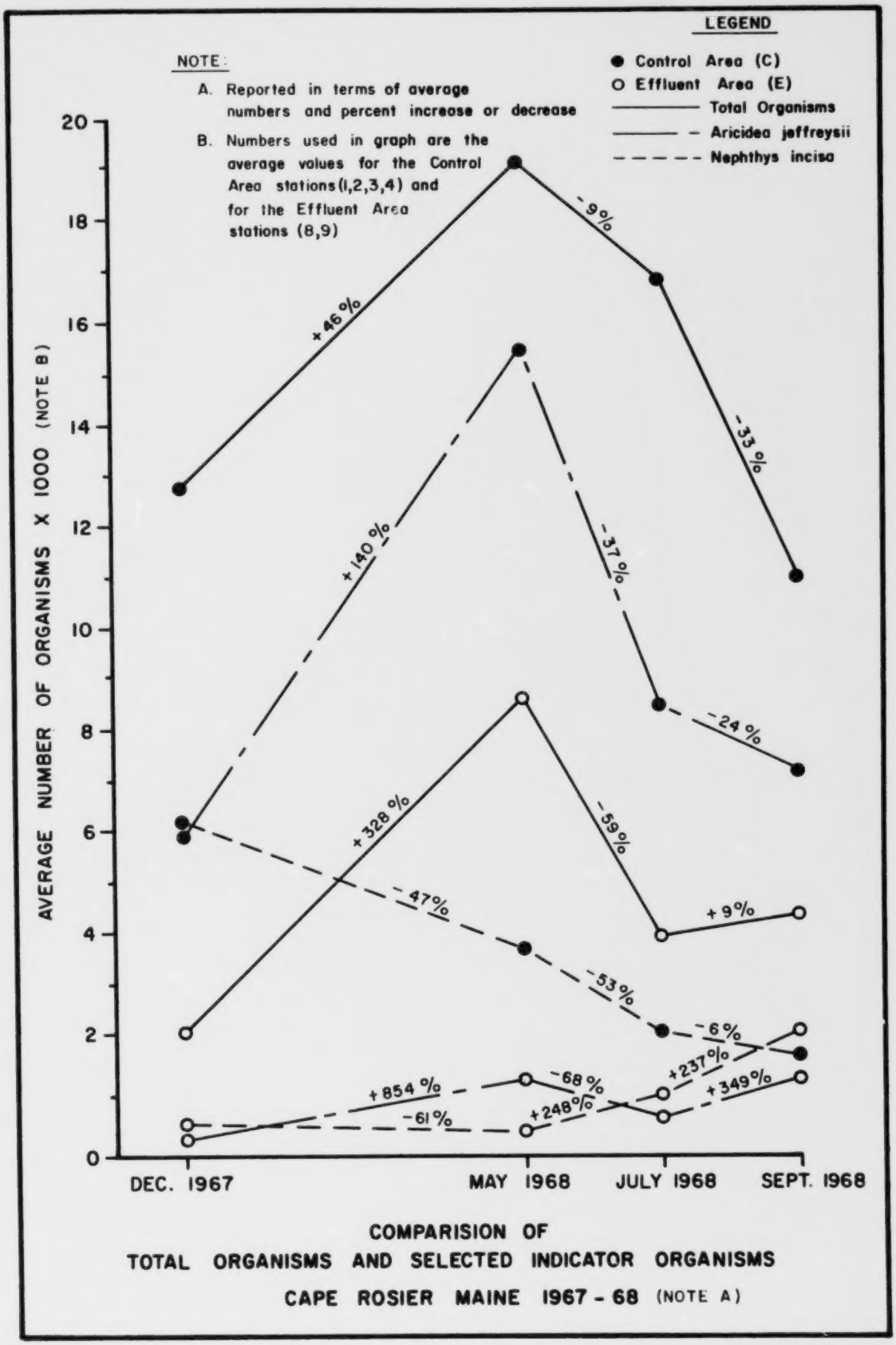
Stations 1, 2, 3, and 4 were selected for comparison with Stations 8 and 9 because of their similar sediment composition and their distance from the strip mine discharge pipe (Fig. 1). Station 7 was too close to the effluent area and Stations 15 and 16 were near the Weir Cove ditch that connects with a fresh water pond near the mining area. The remaining Stations (10, 17, and 19) were not sampled continuously during the survey. The study area will therefore consist of Stations 8 and 9 (the effluent area) and Stations 1, 2, 3, and 4 (the control area).

Data Evaluation of Effluent and Control Areas

The dominant benthic invertebrates, Aricidea jeffreysii and Nephthys incisa, were found in all of the study area stations (Tables A-3 to A-6) and comprised 72% of the total organisms (Table X).

A greater density of the benthic fauna in the first four sampling sites (Stations 1, 2, 3 and 4) indicates the presence of a source of organic enrichment from the Bagaduce River that is not available to Stations 8 and 9.

Values for changes in the percent composition of the benthos from the December to September surveys were used in comparing the control and effluent stations rather than actual numbers. However, the raw data may be found listed in Figure 4.



COMPARISION OF
TOTAL ORGANISMS AND SELECTED INDICATOR ORGANISMS
CAPE ROSIER MAINE 1967 - 68 (NOTE A)

FIGURE 4

Total organisms increased 328% in the effluent area (Stations 8 and 9) from December, 1967 to May, 1968; while increasing 46% in the control stations (1, 2, 3 and 4). This increase of organisms in the effluent area occurred over a four month period during which the strip mine was in operation. Aricidea jeffreysii increased by 140% during this period in the control stations and by 858% in the effluent stations. As the population of Aricidea jeffreysii accelerated dramatically along with total organisms per square meter, the population of Nephthys incisa decreased markedly in both areas. Apparently, Nephthys incisa could not successfully compete with the rapidly increasing Aricidea jeffreysii for the available nutrients.

Seasonal Benthic Population Trends

Nephthys incisa decreased 47% in the control stations and decreased 16% in the effluent stations.

From May to July, a decrease in numbers for all organisms occurred in both areas, except for Nephthys incisa which increased 248% in the effluent stations. This general decline in organisms in both areas indicates the possibility that the carrying capacity of the organic nutrients in the sediments had been reached with inevitable deceleration of population as food availability decreased. During this period of a 59% decline in total organisms and a 68% decline for Aricidea jeffreysii in the effluent area, the competition for food and space lessened for Nephthys incisa, which responded with a strong 248% increase in population.

From July to September, in the effluent area, Nephthys incisa continued with a 23% increase in population while Aricidea jeffreysii reversed its downward trend with a 349% increase during this period. Total organisms increased 9% in the effluent stations. Conversely, the control stations continued the downward trend with a 24% decrease in Aricidea jeffreysii, a 6% decrease in Nephthys incisa, and a 33% decrease in total organisms. In the study area Nephthys incisa appears to be taking advantage of the midsummer reduction of Aricidea jeffreysii by either continuing to increase in numbers (effluent area) or by beginning to level off (control area).

In September, 1968, the effluent stations had an increase in Aricidea jeffreysii, Nephthys incisa, and total organisms over December, 1967. This increase occurred while the strip mine was in operation for approximately seven months. For this same period the control stations had a decline in Nephthys incisa and total organisms.

Juvenile Nephthys incisa were predominent in both the control and effluent stations throughout the survey. (7) The presence of these juveniles suggest that reporduction occurred despite the presence of waste discharge at Station 8 and 9.

Large numbers of the polychaete Prionspio steenstrupi (4,242 per square meter) were found at Station 8 during the May survey and were abundant during the July and September surveys (Tables A-3, A-4 and A-5). This worm feeds on fine particles from the surface sediment where the highest copper concentrations were found in the sediment (26.79 mg/kg) of the

May Survey (Table III).

Also present in large numbers (2,828 per square meter during the May Survey at Station 8) was the filter feeding amphipod Corophium volutator, that strains fine detritus from the sediment (Table A-3).

The presence of large numbers of organisms in the effluent area and the similarity of population trends of Aricidea jeffreysii and Nephthys incisa, total organisms and number of kinds in the study area indicate that there have been no adverse effects to the marine environment caused by the strip-mine waste discharge into Goose Cove.

DISCUSSION

Excessive concentrations of heavy metals present a direct hazard to marine organisms.

Two serious effects may result from the influx of trace metals to the marine environment. The first is the direct deleterious effect which these pollutants may have on marine flora and fauna. Secondly, is the inhibition of photosynthetic efficiency in certain marine plants caused by heavy metals.

Concentrations of copper in excess of 0.05 mg/l have been found to have toxic effects on marine ecosystems. Raymont and Shields (8) found that the polychaete worm Nereis sp. was killed in 4 days when subjected to this concentration of 0.05 mg/l copper. Pringle (9) found the soft-shell clam, Mya arenaria, to be extremely sensitive to copper. Using a 0.2 mg/l concentration at $10^{o}C$ and $20^{o}C$, all clams died within 23 days at the lower temperature, while at the higher temperature, all succumbed in 6 to 8 days. Copper concentrations of less than 0.1 mg/l in marine water have been found to inhibit photosynthetic processes. Zinc, cadmium and lead are similarly toxic.

The inhibition of photosynthesis in marine plants caused by heavy metals is extremely hard to detect in situ. However, its effects over a long time span may be devastating as a reduction of photosynthesis would upset the entire ecological and productive balance of the area in question.

At sub-toxic levels, marine organisms which are used as food, notably clams,

may concentrate metals to a degree which makes them hazardous to human health.

Zinc, copper, cadmium, chromium and lead all have undesirable effects on human health. Briefly, copper and zinc are necessary elements for proper human nutrition and biological function, but excesses can be toxic. Lead, cadmium and chromium are foreign to the human body, are non-essential and serve no beneficial function. (10)

Lead and cadmium tend to accumulate in the body tissue rendering them harmful if one is subjected to small concentrations over a period of time. Chromium is not cumulative.

No standards have been set forth related to maximum allowable concentrations for specific metals in shellfish. This report can only refer to metals at various concentrations which could potentially cause a health problem. Specific conclusions regarding health hazards are left up to the reader.

The concentrations found for zinc and copper are apprently within safe limits from a health standpoint. Emetic concentrations for zinc are reported to range from 675-2280 mg/l. (11) Doses of copper over 100 mg are thought to be injurious.(12) Zinc concentrations are highest at Station 4, Phase IV; Station 8, Phases II, III, IV; and Station 9, Phases II, III.* Copper in general, follows a similar trend for most stations and phases. Station 4, 8, and 9 have the highest values.

*Hereafter, station and proper phase designation will be noted as: Example: 8-11 for Station 8, Phase II.

Cadmium and lead are found in the greatest concentration at Stations 4, 8 and 9 with chromium being highest at Station 1. The fact that these elements are recognized as health hazards is reflected by the limits for drinking water imposed for Cd, Pb, Cr, by WHO International, WHO European, and USPHS. These standards are presented on Table VII.

To point out one possibility of many potential health hazards, let us consider the concentration of lead for Station 8, Phase II (19.5 mg Pb/Kg wet tissue. A reported onset of a case of gastro-enteric plumbism was associated with an alimentary intake of 10 to 15 mg. of lead. (12) An individual consuming a large quantity of clams containing a similar amount of lead could be taken ill, not to mention potential complications from chromium and cadmium.

Cadmium poisoning of humans has resulted from the consumption of foods or liquids left in cadmium-plated containers. Several health departments have had to forbid the use of cadmium-plated food containers and pipes in recognition of the health hazard which can be caused by them.(11)

The presence of significant quantities of lead, cadmium and chromium in the tissue of clams from the entire Cape Rosier coastal sample area indicate other sources of heavy metals enrichment in addition to the mine effluent. According to Colby's Atlas of Hancock County, 1871, there are shown several areas in the proximity of Cape Rosier, Maine waters with known mineralization of metal. These are indicated as "copper"; however, many other elements probably exist as a constituent of the ore bodies. The locations of mines,

active and inactive, and ore bodies are indicated on Figure 1. Natural weathering and leaching of elements, combined with surface runoff and ground water infiltration is the probable means of metals entering into the marine waters. Inactive as well as active mines are of significance when explaining metals in clams and marine waters because a characteristic feature of heavy metal pollution is its persistance in time as well as in space for years after the pollutional operations have ceased. (13)

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APPENDIX

Shellfish Closure

The official closure of shellfishing in Cape Rosier is confined to the flats and waters of that section of Harborside, in the town of Brooksville, Hancock County, between a red painted wood post located in a point of land approximately 200 yard north westerly of the Goose Falls Bridge and a red painted wood post located on a stone pier approximately one mile southwesterly of said point of land. The closure area does not include Goose Falls Cove, which receives the mine processing discharge.

STATION LOCATIONS

CAPE ROSIER, MAINE

Station #	Latitude	Longitude
1	44° 22' 34"	68° 48' 16"
2	44° 22' 28"	68° 47' 51"
3	44° 22' 17"	68° 47' 22"
4	44° 22' 09"	68° 47' 05"
5	44° 22' 03"	68° 48' 51"
6	44° 21' 54"	68° 48' 39"
7	44° 21' 40"	68° 48' 15"
8	44° 21' 22"	68° 48' 39"
9	44° 21' 19"	68° 48' 43"
10	44° 21' 13"	68° 48' 59"
11	44° 19' 37"	68° 49' 10"
14	44° 19' 23"	68° 47' 22"
15	44° 19' 15"	68° 47' 21"
16	44° 19' 16"	68° 46' 53"
17	44° 18' 28"	68° 47' 01"
18	44° 20' 13"	68° 45' 38"
19	44° 20' 41"	68° 49' 23"
20	44° 22' 43"	68° 47' 26"
21	44° 22' 13"	68° 47' 03"
22	44° 26' 08"	68° 46' 57"
23	44° 23' 42"	68° 48' 47"
24	44° 22' 43"	68° 47' 46"
25	44° 21' 34"	68° 45' 55"
26	44° 20' 56"	68° 45' 03"
27	44° 18' 11"	68° 40' 45"
28	44° 24' 50"	68° 30' 58"
29	44° 24' 24"	68° 34' 31"
30	44° 17' 37"	68° 31' 12"
31	44° 15' 38"	68° 34' 41"
32	44° 22' 20"	68° 33' 52"

TABLE A-3

BENTHIC ORGANISMS
PER SQ. METER

CAPE ROSIER, MAINE - DECEMBER 1967

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
POLYCHAETES													
PARAONIDAE													
ARICIDEA JEFFREYSII	672	56	17962	3570	-	112	56	-	-	-	-	-	-
NEPHTYIDAE													
NEPHTYS INCISA	9660	2254	7868	5390	42	70	588	-	140	644	-	-	-
NEPHTYS CAECA	-	-	-	-	-	-	28	-	-	-	-	-	-
NEPHTYS BUCERA	-	-	-	-	-	-	-	-	-	14	-	-	-
NEPHTYS SPP.	-	-	-	-	-	-	-	-	-	84	-	-	-
CAPITELLIDAE													
CAPITELLA CAPITATA	42	-	98	28	-	742	126	-	56	42	-	-	-
PHYLLODOCIDAE													
ETEONE LONGA	14	-	-	-	-	42	14	-	-	28	-	-	-
PHYLLODOCE SPP.	-	-	-	140	-	-	-	-	-	-	-	-	-
SIGALIONIDAE													
PHOLOE MINUTA	-	98	-	42	-	112	1050	-	-	196	-	-	-

TABLE A-3 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
ORBINIIDAE													
SCOLOPLOS ACUTUS	-	-	210	28	-	-	-	-	-	-	-	-	-
OPHELIIDAE													
AMMOTRYPANE AULOGASTER	-	-	14	-	-	-	14	-	-	14	-	-	-
LUMBRINERIDAE													
LUMBRINERIS TENUIS	-	-	14	-	-	-	14	-	-	-	-	-	-
NINOE NIGRIPES	-	-	28	-	14	-	42	-	-	42	-	-	-
LUMBRINERIS FRAGILIS	-	-	-	-	-	-	14	-	-	-	-	-	-
POLYNOIDAE													
HARMOTHOE EXTENUATA	-	-	-	252	-	-	-	-	-	126	-	-	-
LEPIDONOTUS SQUAMATUS	-	-	-	-	-	-	-	-	-	14	-	-	-
SPIONIDAE													
POLYDORA CILIATA	-	-	-	28	-	-	-	-	-	-	-	-	-
SCOLECOLEPIDES VIRIDIS	-	-	-	-	70	196	-	-	-	-	-	-	-
POLYDORA SPP.	-	-	-	-	-	56	14	-	-	-	-	-	-
POLYDORA LIGNI	-	-	-	-	-	-	-	-	-	56	-	-	-
CIRRATULIDAE													
CIRRATULUS GRANDIS	-	-	-	-	-	28	-	-	-	-	-	-	-
NEREIDAE													

TABLE A-3 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
PLATYNEREIS MEGALOPS	-	-	-	-	-	-	-	-	-	28	-	-	-
NEREIS VIRENS	-	-	-	-	-	-	-	-	-	14	-	-	-
AMPHIPODA													
PHOXOCEPHALIDAE													
PHOXOCEPHALUS HOLBOLLI	224	-	-	14	-	98	56	-	-	-	-	-	-
AMPELISCIDAE													
AMPELISCA MACROCEPHALA	602	42	28	154	-	28	-	-	56	-	-	-	-
COROPHIIDAE													
COROPHIUM VOLUTATOR	532	182	14	42	-	42	-	-	-	70	-	-	-
ORCHESTIIDAE													
TRYPHOSA PINGUIS	126	-	14	252	-	-	-	-	-	-	-	-	-
AMPITHOIDAE													
AMPITHOE SPP.	56	-	-	14	-	-	-	-	-	-	-	-	-
UNIDENTIFIED	-	-	-	-	-	-	-	-	-	24	-	-	-
ISOPODA													
EDOTEA TRILOBA	-	56	-	-	-	-	-	-	-	-	-	-	-
BIVALVES													
MYA ARENARIA	14	56	-	112	28	-	-	-	-	-	-	-	-
MYTILUS EDULIS	-	14	-	14	-	-	-	-	14	-	-	-	-

TABLE A-2 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
MACOMA BALTHICA	-	-	-	28	-	-	14	-	-	14	-	-	-
NUCULA PROXIMA	-	-	-	-	154	-	28	-	-	-	-	-	-
YOLDIA LIMATULA	-	-	-	-	14	-	-	-	-	-	-	-	-
PERIPLOMA FRAGILIS	-	-	-	-	224	-	-	-	-	-	-	-	-
UNIDENTIFIED	42	-	-	-	-	-	-	-	28	-	-	-	-
SEA URCHIN													
STRONGYLOCENTROTUS DROBACHIENSIS	-	14	-	14	-	-	42	0	-	-	-	-	-
SAND DOLLAR													
ECHINARACHNIUS PARMA	-	-	-	-	-	-	56	-	-	-	-	-	-
CUMACEANS	14	140	378	42	-	14	-	-	56	-	-	-	-
OSTRACODA	-	-	14	-	-	-	28	-	-	-	-	-	-
CLADOCERA	-	-	-	-	-	14	14	-	-	-	-	-	-
ACARINA	-	-	-	-	-	28	-	-	-	-	-	-	-
NEMATODA	-	14	-	-	-	56	-	-	-	-	-	-	-
TOTAL ORGANISMS	11018	3926	26642	10164	546	1638	2296	1	350	1410	-	-	-
TOTAL KINDS	13	11	12	14	7	15	18	1	6	16	-	-	-

QUANTITATIVE SAMPLE GIVEN AN ARBITRARY VALUE OF 1 IN THE TOTALS

TABLE A-4

BENTHIC ORGANISMS
PER SQ. METER

CAPE ROSIER, MAINE - MAY 1964

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
POLYCHAETES													
PARAONIDAE													
AMICIDEA JEFFREYSTI	518	25746	14714	12558	126	728	882	-	2128	1022	-	518	-
NEPHTYIDAE													
NEPHTYS INCISA	5454	3304	1624	2196	182	70	224	-	896	252	-	1358	-
NEPHTYS PICTA	-	-	14	-	-	-	-	-	-	-	-	-	-
NEPHTYS CAECA	-	-	-	28	-	-	84	-	-	-	-	-	-
CAPITELLIDAE													
CAPITELLA CAPITATA	-	-	-	-	-	350	-	-	280	-	-	-	-
PHYLLODOCIDAE													
PHYLLODOCE GROENLANDICA	-	56	-	-	-	56	-	-	-	-	-	42	-
ETEONE LACTEA	-	-	14	-	-	-	-	-	-	-	-	-	-
ETEONE LONGA	-	-	-	70	-	-	-	-	-	-	-	-	-
ETEONE SPP.	-	-	-	-	-	-	-	-	-	-	-	56	-
SIGALIONIDAE													

TABLE A-4 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
PHOLOE MINUTA	-	-	-	-	-	182	392	-	392	1022	-	-	-
ORBINIIDAE													
SCOLOPLOS ACUTUS	-	-	-	574	-	-	-	-	-	14	-	-	-
SCOLOPLOS ROBUSTUS	-	686	-	-	-	-	-	-	-	-	-	-	-
OPHELIIDAE													
AMMOTRYPANE AULOGASTER	-	14	-	-	-	14	14	-	28	42	-	140	-
LUMBRINERIDAE													
LUMBRINERIS TENUIS	-	-	-	-	-	-	-	-	-	-	-	182	-
NINOE NIGRIPES	-	42	-	14	70	56	28	-	56	574	14	448	-
LUMBRINERIS FRAGILIS	-	-	-	-	-	-	-	-	-	42	-	42	-
POLYNOIDAE													
HARMOTHOE EXTENUATA	-	182	-	-	-	-	-	-	-	-	168	294	-
HARMOTHOE IMBRICATA	-	-	-	-	-	14	-	-	70	-	-	70	-
LEPIDONOTUS SQUAMATUS	-	-	-	14	-	-	-	-	-	-	-	-	-
SPIONIDAE													
POLYDORA CILIATA	-	-	-	-	-	-	-	-	-	1400	-	-	-
SCOLECOLEPIDES VIRIDIS	-	658	56	-	-	-	-	-	-	-	-	2940	-
POLYDORA LIGNI	-	-	-	-	-	14	-	-	-	-	-	-	-
PRIONOSPIO STEENSTRUPI	-	-	-	-	-	4242	-	-	-	-	-	-	-

TABLE A-4 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
SPIO SETOSA	-	-	-	-	952	-	-	-	-	-	-	-	-
CIRRATULIDAE													
CIRRATULUS CIRRATUS	-	-	-	-	-	14	-	-	-	-	-	-	-
GLYCERIDAE													
GLYCERA CAPITATA	42	-	-	-	-	-	-	-	-	-	-	-	-
GLYCERA DIBRANCHIATA	210	-	-	-	-	-	-	-	28	-	-	-	-
FLABELLIGERIDAE													
DIPLOCIRRUS HIRSUTUS	-	56	-	-	-	-	-	-	-	-	-	154	-
PHERUSA AFFINIS	-	-	-	-	-	-	-	-	14	28	-	-	-
AMPHARETIDAE													
AMPHARETE SPP.	-	-	14	-	-	-	-	-	-	-	-	-	-
AMPHICTEIS GUNNERI	-	-	-	-	-	-	-	-	-	-	-	56	-
UNIDENTIFIED	-	-	-	-	-	28	-	-	-	-	-	-	-
STERNASPIDAE													
STERNASPIS FOSSOR	-	-	-	-	42	-	-	-	-	-	-	-	-
TEREBELLIDAE													
UNIDENTIFIED	-	-	-	-	-	14	-	-	-	-	-	-	-
MALDANIDAE													
CLYMENELLA TORQUATA	-	-	-	-	-	-	14	-	-	-	-	-	-

TABLE A-4 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
ARABELLIDAE													
ARABELLA IRICOLOR	-	-	-	-	-	-	-	-	-	98	-	-	-
SYLLIDAE													
UNIDENTIFIED	-	-	42	-	-	-	-	-	-	-	-	-	-
UNIDENTIFIED	-	-	420	-	294	42	938	-	-	-	-	-	-
AMPHIPODA													
PHOXOCEPHALIDAE													
PHOXOCEPHALUS HOLBOLLI	56	-	-	28	-	434	70	-	-	98	-	-	-
PARAPHOXUS SPINOSUS	-	-	-	-	-	42	14	-	28	-	-	-	-
AMPELISCIDAE													
AMPELISCA MACROCEPHALA	238	70	-	140	-	518	-	-	14	168	-	154	-
AMPELISCA SPINIPES	-	-	-	-	-	-	14	-	-	-	-	-	-
UNIDENTIFIED	-	-	-	-	56	-	-	-	-	-	-	-	-
CORophiidae													
CORophium VOLUTATOR	378	126	-	1218	-	2828	546	-	56	4970	-	56	-
CORophium CYLINDRICUM	-	42	-	-	-	-	-	-	-	-	-	-	-
ORCHESTIIDAE													
TRYPHOSA NUGUTS	-	-	-	-	-	280	-	-	-	168	-	-	-
AMPITHOIDAE													

TABLE A-4 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
AMPITHOE SPP.	280	-	-	70	-	532	-	-	-	126	-	-	-
AMPITHOE RUBRICATA	-	-	-	-	-	-	-	-	-	-	14	-	-
GRURIA CONPTA	-	-	-	-	-	-	-	-	-	-	14	-	-
LYSIANASSIDAE													
LYSIANOPSIS ALBA	56	-	-	-	-	-	-	-	-	-	-	-	-
AMONYX NUBAX	-	210	-	-	-	-	-	-	-	-	-	-	-
GAMMARIDAE													
GAMMARUS LOCUSTA	-	14	-	-	-	14	-	-	-	-	-	14	-
MELITA DENTATA	-	-	-	28	-	-	-	-	-	-	-	-	-
GAMARUS SPP.	-	-	-	-	-	-	14	-	-	-	-	-	-
GAMMARUS MARINUS	-	-	-	-	-	-	-	-	-	-	14	-	-
PHOTIDAE													
LEPTOCHEIRUS PINGUIS	-	112	-	14	-	-	70	-	-	-	-	-	-
CALLIOPIIDAE													
CALLIOPIUS LAEVIUSCULUS	-	-	-	14	-	-	-	-	-	-	-	-	-
TALITRIDAE													
TALORCHESTIA LONGICORNIS	-	-	-	-	-	-	-	-	-	-	-	28	-
JASSIDAE													
JASSA MARMORATA	-	-	-	-	-	-	-	-	-	-	-	14	-

TABLE A-4 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
STEROCEPHALIDAE													
STEGOCEPHALUS INFLATUS	-	-	-	-	-	-	-	-	-	-	-	14	-
CAPRELLIDEA	-	-	-	-	14	-	-	-	-	-	-	-	-
UNIDENTIFIED	-	434	56	-	98	14	84	-	-	-	-	14	-
ISOPODA													
CYATHURA CARINATA	112	-	-	-	-	-	-	-	-	-	-	-	-
GNATHIA SPP.	56	-	-	-	-	-	-	-	-	-	-	-	-
EDOTEA TRILOBA	-	-	-	-	-	14	-	-	-	14	-	-	-
JAERA MARINA	-	-	-	-	-	-	-	-	-	-	14	-	-
UNIDENTIFIED	-	-	-	-	56	-	28	-	-	-	-	-	-
BIVALVES													
MYA ARENARIA	-	-	-	-	-	-	42	-	56	-	-	-	-
MYTILUS EDULIS	-	-	-	-	-	14	-	-	-	-	308	-	-
MACOMA BALTHICA	-	-	-	70	-	-	-	-	-	-	-	-	-
MUCULA ANNULATA	-	-	-	-	-	-	-	-	-	126	-	-	-
TELLINA AGILIS	-	-	-	-	-	-	28	-	28	-	-	-	-
SPISULA SOLIDISSIMA	-	-	-	-	-	-	-	-	-	-	-	154	-
UNIDENTIFIED	-	-	-	-	-	-	28	-	28	-	-	-	-
SEA URCHIN													

TABLE A-4 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
STRONGYLOCENTROTUS DROBACHIENSIS	14	-	-	-	-	14	14	0	14	84	-	-	-
SAND DOLLAR													
ECHINARACHNIUS PARMA	-	-	-	-	-	-	56	-	-	-	-	-	-
CUMACEANS	-	-	238	84	630	28	-	-	952	126	-	14	-
OSTRACODS	-	-	-	-	56	-	-	-	-	-	-	-	-
GASTROPODS													
NASSARIUS TRIVITTATUS	-	-	-	-	-	-	14	-	-	-	-	-	-
LITTORINA OBTUSATA	-	-	-	-	-	-	-	-	14	-	-	-	-
LITTORINA LITTOREA	-	-	-	-	-	-	-	-	84	-	168	-	-
ACMAEA TESTUDINALIS	-	-	-	-	-	-	-	-	84	28	-	-	-
CHITONS													
CHAETOPLEURA APICULATA	-	-	-	-	-	-	-	0	-	-	-	-	-
TRACHYDERMEN RUBER	-	-	-	-	-	-	-	0	-	-	-	-	-
NEMATODES	224	-	70	-	-	1274	1428	-	-	98	31920	140	-
BRITTLE STAR													
OPHIOPHOLIS ACULEATA	-	-	-	-	-	-	-	0	-	-	-	-	-
AMPHIPOLIS SQUAMATA	-	-	-	-	-	-	-	-	14	-	-	-	-
OLIGOCHAETS	-	-	-	-	-	-	-	-	-	-	7910	-	-
TOTAL ORGANISMS	7840	31822	1'242	17122	2576	11830	9026	4	5264	10500	40544	6902	-

TABLE 4-4 (CONT.)

TAXA	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
TOTAL TAXA	13	14	11	10	12	27	23	4	21	21	10	23	-

QUANTITATIVE SAMPLE GIVEN AN ARBITRARY VALUE OF 1 IN THE TOTALS

TABLE A-5

BENTHIC ORGANISMS
PER SQ. METER

CAPE ROSIER, MAINE - JULY, 1948

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
POLYCHAETES													
PARAONIDAE													
APHELOCHAETA JEFFREYSII	756	24672	574	3752	98	196	322	-	-	322	-	126	84
PARAONIS FULGENS	-	-	-	-	70	-	-	-	-	-	-	-	-
NEPHTYIDAE													
NEPHTYS INCISA	14	4928	574	504	140	182	840	-	910	2730	14	1120	14
NEPHTYS CAECA	-	-	-	-	-	-	84	-	-	-	-	-	-
NEPHTYS PICTA	-	-	-	-	-	-	-	-	-	-	-	-	14
CAPITELLIDAE													
CAPITELLA CAPITATA	42	240	246	252	532	448	812	-	182	420	434	1148	42
PHYLLODOCIDAE													
PHYLLODOCE GROENLANDICA	-	-	-	98	-	-	-	-	84	294	98	420	42
ETEONE LACTEA	84	42	-	-	-	42	28	-	-	-	-	-	-
[illegible]	-	-	-	-	-	-	-	-	98	-	-	-	-
SIGALIONIDAE													

TABLE A-4 (CONT.)

TAXA	STATION NUMBER													
	1	2	3	4	7	8	9	10	15	16	17	18	19
PHOLOE MINUTA	-	196	-	-	-	224	98	-	-	-	-	-	-
UNIDENTIFIED	112	-	-	-	-	-	-	-	-	-	-	-	-
ORBINIIDAE													
SCOLOPLOS ACUTUS	154	1036	14	308	14	-	-	-	-	-	-	-	-
SCOLOPLOS ROBUSTUS	-	-	-	-	-	-	-	-	-	98	-	14	42
SCOLOPLOS SPP.	-	-	-	-	-	-	-	-	14	-	-	-	-
OPHELLIDAE													
ARMANDIA BILOBATA	-	14	-	42	14	-	56	-	28	168	196	140	-
LUMBRINERIDAE													
LUMBRINERIS TENUIS	14	-	-	14	-	14	28	-	-	28	-	-	-
NINOE NIGRIPES	14	56	-	42	112	-	-	-	28	504	28	224	-
LUMBRINERIS FRAGILIS	14	28	14	-	-	-	-	-	-	-	-	-	-
UNIDENTIFIED	-	14	-	-	-	-	-	-	-	-	-	-	-
POLYNOIDAE													
HARMOTHOE EXTENUATA	70	-	-	294	182	-	-	-	28	140	378	938	644
HARMOTHOE IMBRICATA	-	126	14	70	-	14	-	-	-	-	-	-	-
SPIONIDAE													
SCOLECOLEPIDES VIRIDIS	-	-	-	-	-	-	-	-	448	798	1302	3598	42
POLYDORA LIGNI	-	-	-	42	-	-	28	-	70	-	-	-	112

TABLE A-6 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
PRIONOSPIO STEENSTRUPI	966	448	14	1190	-	952	1288	-	-	-	-	-	-
POLYDORA SPP.	84	14	-	-	-	-	-	-	-	-	-	-	-
CIRRATULIDAE													
CIRRATULUS CIRRATUS	-	70	-	-	-	14	-	-	-	-	-	266	-
CIRRATULUS GRANDIS	-	-	-	14	42	-	-	-	168	-	98	-	56
CIRRATULUS SPP.	-	-	14	-	-	-	-	-	-	-	-	-	-
FLABELLIGERIDAE													
DIPLOCIRRUS HIRSUTUS	-	-	-	14	-	-	-	-	28	-	-	42	-
AMPHARETIDAE													
AMPHICTEIS GUNNERI	-	-	-	42	84	-	322	-	-	168	-	112	-
AMPHARETE GRACILIS	-	42	-	-	-	-	-	-	-	-	-	-	-
TEREBELLIDAE													
TEREBELLIDES STROEMI	-	-	-	14	56	-	-	-	-	-	-	-	-
MALDANIDAE													
CLYMENELLA TORQUATA	476	-	42	-	-	-	56	-	-	-	-	-	-
CLYMENELLA ZONALIS	-	-	14	-	-	-	-	-	-	-	-	-	-
UNIDENTIFIED	-	-	-	-	56	-	-	-	-	-	-	-	-
COSSURIDAE													
COSSURA LONGOCIRRATA	42	98	70	-	112	-	-	-	-	-	-	-	-

TABLE A-8 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
NEREIDAE													
NEREIS SPP.	-	-	168	-	-	-	-	-	-	-	-	-	-
NEREIS ARENACEODONTA	-	-	-	-	-	-	168	-	28	-	-	14	14
UNIDENTIFIED	-	-	-	28	-	-	-	-	-	-	-	-	-
PECTINARIIDAE													
PECTINARIA GOULDII	-	-	-	14	-	-	-	-	-	-	14	70	14
SABELLIDAE													
POTAMILLA NEGLECTA	-	-	-	-	14	-	-	-	-	-	-	14	14
APISTOBRANCHIDAE													
APISTOBRANCHUS TULLBERGI	-	-	-	-	1414	-	-	-	-	-	-	-	-
AMPHIPODA													
PHOXOCEPHALIDAE													
PHOXOCEPHALUS HOLBOLLI	2114	42	28	1652	-	28	-	-	14	-	224	-	420
AMPELISCIDAE													
AMPELISCA MACROCEPHALA	182	98	-	98	-	-	56	-	14	42	-	56	-
CORophiidae													
CORophium VOLUTATOR	1246	1288	-	3220	-	70	112	-	-	1484	196	98	182
DULICHIA PORRECTA	14	-	-	-	-	-	-	-	-	-	-	-	-
ORCHESTIIDAE													

TABLE A-8 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
TRYPHOSA PINGUIS	980	98	-	42	-	-	-	-	-	-	-	-	-
ALLORCHESTES LITTORALIS	-	-	-	378	-	-	-	-	140	238	-	42	-
AMPITHOIDAE													
AMPITHOE SPP.	5082	588	98	-	-	28	126	-	-	-	-	-	-
GAMMARIDAE													
GAMMARUS LOCUSTA	-	-	-	-	-	-	-	-	-	-	42	-	-
MELITA DENTATA	-	-	-	392	-	-	-	-	14	-	-	-	-
GAMMARUS MARINUS	-	-	-	672	-	-	-	-	-	-	-	-	-
CAPRELLIDEA	-	-	-	-	-	14	-	-	-	-	-	-	-
UNIDENTIFIED	168	112	-	-	28	-	-	-	-	910	-	84	-
MYSIDACEA													
METERYTHROPS ROBUSTA	-	-	-	-	-	-	-	-	-	-	-	-	28
BIVALVES													
MYA ARENARIA	84	-	14	-	70	-	-	-	126	-	-	-	70
MYTILUS EDULIS	-	-	-	-	-	-	-	-	-	-	-	-	14
MACOMA BALTHICA	42	28	-	-	-	14	14	-	-	-	-	-	-
NUCULA PROXIMA	14	-	-	-	70	14	-	-	-	-	-	-	-
TELLINA AGILIS	-	-	-	-	-	-	14	-	-	-	-	14	-
MACOMA TENTA	-	-	-	-	-	-	-	-	-	-	-	-	98

TABLE 4-B (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
LYONSIA HYALINA	14	-	-	-	-	-	-	-	-	-	-	-	84
CARDITA BOREALIS	28	-	-	-	-	-	-	-	-	-	-	-	-
PERIPLOMA FRAGILIS	-	-	-	-	266	-	-	-	-	-	-	-	-
SPISULA SOLIDISSIMA	-	-	-	-	-	-	-	-	-	-	-	196	-
SAND DOLLAR													
ECHINARACHNIUS PARMA	-	-	-	-	-	14	-	-	-	-	-	-	182
CUMACEANS	42	294	14	98	210	14	-	-	154	14	-	42	84
OSTRACODS	-	-	-	-	266	14	42	-	-	-	-	-	-
GASTROPODS													
NASSARIUS TRIVITTATUS	-	-	-	-	-	-	-	-	-	-	-	-	14
ACHAEA TESTUDINALIS	-	-	-	-	-	-	-	-	-	-	-	14	-
UNIDENTIFIED	-	-	14	-	-	-	-	-	-	-	-	-	-
NEMATODES	14	-	-	-	-	42	126	-	-	-	-	28	2800
ACARINA	-	-	-	-	-	-	28	-	-	-	-	-	-
TOTAL ORGANISMS	12866	39410	1946	13286	3850	2338	4620	-	2044	8316	2996	8120	5110
TOTAL KINDS	28	34	17	26	21	19	21	-	19	16	12	24	24

0=QUALITATIVE SAMPLE-GIVEN AN ARBITRARY VALUE OF 1 IN THE TOTALS

TABLE A-6

BENTHIC ORGANISMS
PER SQ. METER

CAPE ROSIER, MAINE - SEPTEMBER, 1968

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
POLYCHAETES													
PARAONIDAE													
APICIDEA JEFFREYSII	749	17436	5082	2324	322	70	2254	-	14	448	-	-	196
NEPHTYIDAE													
NEPHTYS INCISA	14	2618	2996	56	112	994	2450	-	70	1890	-	364	14
CAPITELLIDAE													
CAPITELLA CAPITATA	-	42	-	-	14	70	140	-	56	14	-	-	-
NOTOMASTUS LURIDUS	-	-	-	-	42	-	-	-	14	-	-	-	-
PHYLLODOCIDAE													
PHYLLODOCE GROENLANDICA	-	14	-	-	-	-	42	-	-	140	-	-	-
ETEONE LACTEA	-	56	14	-	-	-	14	-	14	-	-	-	-
ETEONE LONGA	-	42	28	-	-	-	-	-	-	-	-	-	-
PARANAITIS SPECIOSA	-	14	-	-	-	-	-	-	-	-	-	-	-
EULALIA BILINEATA	-	-	-	-	-	-	-	-	154	14	-	-	-
SIGALIONIDAE													

TABLE A-4 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
PHOLOE MINUTA	14	196	-	14	-	-	70	-	-	-	0	-	-
ORBINIIDAE													
SCOLOPLOS ACUTUS	252	952	378	14	42	-	56	-	-	-	-	-	126
OPHELIIDAE													
AMMOTRYPANE AULOGASTER	-	-	-	-	-	-	14	-	-	14	-	-	-
LUMBRINERIDAE													
LUMBRINERIS TENUIS	-	14	14	-	14	-	-	-	-	-	-	-	-
NINOE NIGRIPES	-	28	-	-	154	-	28	-	-	224	-	-	-
LUMBRINERIS FRAGILIS	-	-	-	-	14	-	-	-	-	-	-	-	-
POLYNOIDAE													
HARMOTHOE EXTENUATA	-	42	-	-	42	-	-	-	-	14	-	-	-
HARMOTHOE IMBRICATA	-	-	-	14	-	-	-	-	-	-	-	-	-
SPIONIDAE													
POLYDORA LIGNI	-	56	42	-	-	-	-	-	14	-	-	-	-
PRIONOSPIO STEENSTRUPI	210	406	84	42	-	378	490	-	14	1330	-	14	-
POLYDORA SPP.	-	-	14	-	-	-	-	-	-	-	-	-	-
CIRRATULIDAE													
CIRRATULUS CIRRATUS	-	56	-	-	-	-	-	-	-	14	-	-	-
CIRRATULUS GRANDIS	140	-	-	-	-	-	-	-	-	14	-	-	-

TABLE A-4 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
FLABELLIGERIDAE													
DIPLOCIRRUS HIRSUTUS	70	-	-	-	-	-	-	-	-	42	-	-	-
PHERUSA PLUMOSA	14	-	-	-	-	-	-	-	-	-	-	-	-
AMPHARETIDAE													
AMPHARETE ACUTIFRONS	14	84	-	-	-	-	-	-	-	154	-	-	-
AMPHICTEIS EXTENUATA	-	-	-	-	42	-	-	-	-	-	-	-	-
AMPHICTEIS GUNNERI	-	-	-	-	-	70	-	-	-	-	-	-	-
TEREBELLIDAE													
TEREBELLIDES STROEMII	14	-	-	-	28	-	-	-	-	-	-	-	-
MALDANIDAE													
CLYMELLA TORQUATA	-	70	-	84	-	-	-	-	-	-	-	-	-
CLYMELLA ZONALIS	154	-	-	-	-	-	-	-	-	-	-	-	-
MALDANOPSIS ELONGATA	-	-	-	-	14	-	-	-	-	-	-	-	-
COSSURIDAE													
COSSURA LONGOCIRRATA	28	28	266	-	14	-	-	-	-	-	-	-	-
NEREIDAE													
NEREIS ARENACEODONTA	-	-	28	-	-	-	-	-	-	-	-	-	-
PECTINARIIDAE													
PECTINARIA GOULDII	140	-	-	14	28	-	-	-	14	-	-	-	-

TABLE A-6 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
APISTOBRANCHIDAE													
APISTOBRANCHUS TULLBERGI	-	56	98	-	1204	-	-	-	14	-	-	-	-
AMPHIPODA													
PHOXOCEPHALIDAE													
PHOXICEPHALUS HOLBOLLI	1218	14	-	686	-	-	14	-	-	-	-	-	126
AMPELISCIDAE													
AMPELISCA MACROCEPHALA	994	56	-	70	42	-	56	-	-	-	-	-	-
CORophiidae													
CORophium VOLUTATOR	938	1288	-	42	-	84	42	-	-	-	-	-	-
ORCHESTIIDAE													
TRYPHOSA PINGUIS	483	280	-	-	-	-	-	-	-	-	-	-	-
ALLORCHESTES LITTORALIS	1316	-	-	-	-	-	-	-	28	-	-	-	-
AMPITHOIDAE													
AMPITHOE SPP.	-	28	56	294	-	-	14	-	-	-	-	-	14
GAMMARIDAE													
MELITA DENTATA	14	-	-	-	-	-	-	-	-	-	-	-	-
GAMMARUS MARINUS	42	-	-	-	-	-	-	-	-	-	-	-	-
UNIDENTIFIED	-	308	-	98	14	-	-	-	-	-	-	14	-
BIVALVES													

TABLE A-6 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
MYA ARENARIA	-	-	-	-	70	14	-	-	-	-	-	-	14
MYTILUS EDULIS	42	-	-	14	-	14	-	-	14	-	-	-	14
MACOMA BALTHICA	28	28	-	-	-	28	-	-	-	-	-	-	-
NUCULA PROXIMA	84	-	-	-	42	14	84	-	-	-	-	-	-
TELLINA AGILIS	28	-	-	-	-	-	-	-	-	-	-	-	-
CARDITA SPP.	-	-	-	-	-	-	-	-	-	-	-	-	14
PERIPLOMA FRAGILIS	-	-	-	-	84	-	-	-	-	-	-	-	-
UNIDENTIFIED	-	-	-	-	-	14	42	-	-	-	-	-	-
SAND DOLLAR													
ECHINARACHNIUS PARMA	-	-	-	-	-	-	-	-	-	-	-	-	252
MYSIDACEA													
METERYTHROPS ROBUSTA	-	-	-	-	-	-	-	-	14	-	-	-	-
SEA URCHIN													
STRONGYLOCENTROTUS DROBACHIENSIS	-	-	-	-	-	-	-	-	-	9	-	42	-
CUMACEANS	-	290	14	98	266	-	-	-	-	-	-	-	14
OSTRACODS	-	-	-	28	-	-	-	-	-	-	-	-	-
ISOPODA													
EDOTEA TRILOBA	28	-	-	-	-	-	-	-	-	-	-	-	28
GASTROPODS													

TABLE 4-6 (CONT.)

KINDS	STATION NUMBER												
	1	2	3	4	7	8	9	10	15	16	17	18	19
LITTORINA LITTOREA	78	-	-	-	-	-	-	-	-	-	Q	-	-
NASSARIUS TRIVITTATUS	56	-	-	-	-	-	-	-	-	-	-	-	-
ACMAEA TESTUDINALIS	-	-	-	-	-	-	-	-	-	-	Q	-	-
UNIDENTIFIED	-	-	-	-	-	-	-	-	96	-	-	-	-
DECAPOD													
PAGURUS POLLICARIS	-	-	-	-	-	-	14	-	-	-	-	-	-
STARFISH													
ASTERIAS FORBESI	-	-	-	-	-	-	-	-	28	-	-	-	-
NEMATODES	-	-	-	-	98	-	-	-	-	-	-	-	854
TOTAL ORGANISMS	7518	24752	9114	3892	2702	1750	5824	-	418	4312	4	392	1666
TOTAL KINDS	27	37	14	16	22	11	17	-	15	13	4	3	13

Q=QUALITATIVE SAMPLE GIVEN AN ARBITRARY VALUE OF 1 IN THE TOTALS